HONORABLE GEORGE J. JORDAN
ADMINISTRATIVE LAW JUDGE

UNITED STATES OF AMERICA
DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

In re: **Proposed Waiver and Regulations Governing the Taking of Eastern North Pacific Gray Whales by the Makah Indian Tribe**	Docket No. 19-NMFS-0001 RIN: 0648-BI58 and RIN: 0648-XG584

SECOND DECLARATION OF DR. DAVID WELLER

I, Dr. David Weller, declare as follows:

1. I am a wildlife research biologist with the Marine Mammal and Turtle Division of the National Marine Fisheries Service (NMFS) Southwest Fisheries Science Center (SWFSC), within the National Oceanic and Atmospheric Administration (NOAA). This is the second declaration I have submitted in this matter. I incorporate by reference paragraphs 1-5 of my first declaration, filed April 5, 2019, which explain my qualifications and expertise to testify in this matter.

2. I have reviewed the following declarations submitted by other parties to this proceeding: Declaration of DJ Schubert dated May 20, 2019, submitted by the Animal Welfare Institute; Declaration of Margaret Owens dated May 17, 2019, submitted by Peninsula Citizens for the Protection of Whales; Declaration of Jonathan Scordino dated May 15, 2019, submitted by the Makah Indian Tribe; Declaration of Dr. John W. Bickham dated May 17, 2019, submitted

by the Makah Indian Tribe; and Declaration of Dr. John R. Brandon dated May 16, 2019, submitted by the Makah Indian Tribe. I have also reviewed the list of "Issues to be Addressed at the Hearing" as stated in the "Announcement of Hearing and Final Agenda Regarding Proposed Waiver and Regulations Governing the Taking of Marine Mammals," 84 *Federal Register* 30,088, 30,089 (2019) (Final Hearing Agenda), with particular focus on those issues related to the information provided in my first declaration or otherwise within my areas of expertise. I submit this declaration to respond to certain information provided in the other parties' declarations listed above, focusing on those issues related to my initial direct testimony, and in support of NMFS's proposed waiver and regulations.

ENP GRAY WHALE STOCK

DISTRIBUTION AND ABUNDANCE

3. Issue I.A.1(a) from the Final Hearing Agenda asks what numbers are appropriate to use for ENP, WNP, and PCFG carrying capacity, current abundance, population stability and/or historical fluctuation, and optimum sustainable population (OSP) levels. The Second Declaration of Dr. Shannon Bettridge identifies the best available estimates for these parameters, as relevant, based on the recently-issued 2018 Stock Assessment Reports (SARs) for the ENP stock and the WNP stock. Second Bettridge Decl. ¶¶ 5-7. The Second Declaration of Dr. Jeffrey Moore, filed herewith, describes the information needed in order to calculate carrying capacity and OSP for a marine mammal stock. Second Moore Decl. ¶¶ 3-4. As Dr. Moore explains, we do not at this time have sufficient information to calculate carrying capacity and OSP levels for the WNP stock or for the PCFG. I discuss the most recent abundance estimates for the WNP stock further in paragraph 30 below.

4. I am aware that NMFS recently declared an unusual mortality event (UME) for the ENP gray whale stock. The Fourth Declaration of Chris Yates and the Third Declaration of Dr. Bettridge (filed herewith) explain in detail the framework and process governing UMEs and the information available to date regarding the 2019 ENP gray whale UME.

5. As explained in paragraph 22 of my first declaration, NMFS previously declared a UME for ENP gray whales in 1999. During that event, approximately 24 percent of the ENP stock died. *See* Fourth Yates Decl. ¶ 5. Many, but not all, of the stranded whales were in poor nutritional condition, which indicates that starvation could have been an important contributing factor, but the underlying cause of the widespread starvation is unknown, and thus the cause of the UME remains unknown. Some scientists speculate it was climate related, others that it was the result of the stock reaching the carrying capacity of its habitat, and still others that it was a combination of those two causes. Fourth Yates Decl. ¶ 4. Following the 1999/2000 die-off, the ENP stock rebounded, and the stock's current abundance estimate of 26,960, is the highest recorded during any of the 1967-2016 surveys conducted to estimate abundance.

6. Paragraphs 27-30 of Mr. Schubert's Declaration assert that the ENP stock's carrying capacity in the summer feeding areas is being reduced because of climate change (see Final Hearing Agenda as Issue 1.A.1(d)), which constitutes a risk to the ENP stock. Mr. Schubert cites Ronzón-Contreras *et al*. (2019) (attached as NMFS Exhibit 3-85) as reporting that a decline in food availability for gray whales in their summer feeding grounds is "becoming a problem" as evidenced by the declining condition of the whales observed in 2019. Schubert Decl. ¶ 25. I am familiar with the Ronzón-Contreras *et al*. (2019) paper cited by Mr. Schubert. In my opinion, their conclusion that food availability for ENP gray whales in the summer feeding grounds is "becoming a problem" is premature. The Arctic environment where gray whales feed

is variable, and food availability will be limited in some years, leading to higher mortality and poor reproduction. This will be exacerbated as the population hovers at or near carrying capacity (*i.e.* density-dependence). Short-term patterns and long-term trends should not be confused, as seems to be the case with the cited conclusion from Ronzón-Contreras *et al.* 2019. *See* NMFS Ex. 3-85 (Ronzón-Contreras *et al.* 2019). Gray whale calf production data collected off central California between 1994-2018 add the necessary context to counter the argument made by Ronzón-Contreras *et al.* 2019. *See* NMFS Ex. 3-86 (Weller and Perryman 2019). That is, calf production for ENP gray whales is highly variable on an annual basis. While some years or series of years can have high or low numbers of calves produced, there is no clear long-term pattern to suggest that food limitation is "becoming a problem." Gray whales in poor body condition were observed previously during the 1999-2000 UME. In that case, observations of stranded whales decreased to normal levels in the course of about one year, body condition of whales improved, and there were no lasting population impacts in terms of abundance or calf production. Given this pattern of cyclic population decline and recovery, I do not agree that there is scientific evidence to support the statement that food limitation is "becoming a problem" over the long-term (*i.e*., trending toward being a more regular or frequent occurrence).

7. Presently it is not possible to directly assess how the changing Arctic environment, where a majority of ENP gray whales feed, might impact them over the long-term. The ENP population reached a record high abundance in 2016 (~27,000) and recently (2012-2017), calf production was routinely high suggesting that any potential impacts on prey availability, migratory timing, and other important biological parameters have yet to materialize.

8. Mr. Schubert also asserts that climate change and particularly the "blob" (a large warm water mass) could potentially trigger a "domino effect" and diminish the number of PCFG

whales. Schubert Declaration ¶ 29. Mr. Schubert's assertion is speculative. He notes that at its peak (presumably winter 2013 through 2015 based on the Welch 2016 article he cites), "the blob" stretched from Alaska to Mexico. However, in reviewing the cited article, I note that the author states "not all of what the blob produced is a harbinger of something. Given warming over decades, rather than the blob's span of roughly two years, plants and animals may adapt or move." Schubert Decl. Ex. 21, at 12. To underscore the uncertainty about any "domino effect," I note that PCFG abundance estimates were the highest ever reported during the cited peak "blob" years of 2013-2015. NMFS Ex. 3-33 (Calambokidis *et al.* 2017).

9. Paragraph 26 of Mr. Schubert's declaration states it is likely that the carrying capacity of gray whale habitat has decreased in the last 19 years (*i.e.*, since the last UME). I disagree. The theory that carrying capacity for gray whales has decreased in the last 19 years is difficult to reconcile with the overall increase in population abundance and many years of high calf production during the same time period. Carrying capacity is not a hard ceiling but rather a shifting threshold that is subject to change year to year or over a series of years. The shifting nature of this ecological construct highlights the importance of long-term monitoring of population abundance and calf production, as is conducted by NOAA.

10. In paragraph 26 of his declaration, Mr. Schubert asserts that if the ENP stock has met or exceeded its carrying capacity, this should be a "red flag" for NMFS in considering whether to issue a waiver. I do not agree that a population meeting or exceeding the ecosystem carrying capacity would be a "red flag" concern in and of itself. Instead, a population that has grown to its carrying capacity has, in practice, met the goals of the MMPA.

11. In my first declaration, I explain the background of the catch limit established by the International Whaling Commission (IWC) for ENP gray whales and the bilateral agreements

between the United States and the Russian Federation that allocate the catch limit between the two countries. Weller Decl. ¶ 9. Mr. Schubert disputes my statement that, based on long-standing practice, the United States would likely transfer any unused allocation to the Russian Federation for use by Chukotkan Natives, who have customarily harvested all or most of the available allocation. Schubert Decl. ¶ 83. Mr. Schubert's characterization of the Chukotkans' use of past allocations is not entirely correct.

12. Since 1997, NMFS has transferred its unused quota of four gray whales per year to Russia for use by Chukotka hunters and would likely continue that practice in the future. Weller Decl. ¶ 9. Mr. Schubert claims that over the past 10 years, the overall gray whale quota was 135 per year, but the Chukotkans took only 122.6 on average per year during that period. Schubert Decl. ¶ 83. Mr. Schubert mischaracterizes the quota. During the 10-year period (2008 to 2017) in the IWC table to which Mr. Schubert cites, the IWC Schedule specifies a total quota of 620 whales for the five-year blocks from 2003-2007 and 2008-2012 and a total quota of 744 whales for the six-year block from 2013-2018, which is equivalent to an average annual quota of 124. *See* NMFS Ex. 3-3 (IWC 2018a) For those time periods, the Schedule also specifies that no more than 140 whales may be taken in any given year; however, to remain below the five- or six-year total quotas, 140 whales cannot not be taken *each* year. During the 10-year time period from 2008 to 2017, the Chukotkans took an average of 125 whales per year, not 122.6. NMFS Ex. 3-87 (IWC 2019).[1] The Chukotkans also exceeded the 2003-2007 and 2008-2012 total quotas (harvested 628 and 635 whales, respectively). Beginning in 2019, the average annual quota increased from 124 to 140 whales per year. NMFS Ex. 3-3 (IWC 2018a). While it

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[1] NMFS Exhibit 3-87 is the table to which Mr. Schubert refers in paragraph 83 of his declaration. For use as an exhibit, NMFS printed the table on July 31, 2019 from the website *https://iwc.int/table_aboriginal*.

remains to be seen whether the Chukotka natives would harvest up to that full amount if allowed, the record reveals years in which they have harvested as many as 143 whales in one year. NMFS Ex. 3-87, at 4 (IWC 2019).

13. My first declaration (paragraphs 16-20) explains that the best available scientific evidence supports including the Pacific Coast Feeding Group (PCFG) within the broader ENP gray whale stock at this time. Mr. Schubert asserts that the IWC considers PCFG gray whales to be a separate stock. Schubert Decl. ¶ 40. This is not entirely accurate. The IWC does not utilize the definition of "population stock" contained in the MMPA. Generally, the IWC uses data regarding range, distribution, movements, genetic structure, mixing rates, and morphology to identify stocks. For management purposes, the IWC may identify a management stock or a management unit that may or may not be equivalent to a single biological stock as defined under the MMPA. The IWC has reached no conclusions regarding recruitment mechanisms for the PCFG and treats the PCFG as a management unit for purposes of evaluating ENP gray whale catch limits.

14. My first declaration identifies the best available abundance estimate for the PCFG as 243 animals. Weller Decl. ¶ 26. This information is also reflected in the 2018 ENP Gray Whale SAR. Second Bettridge Decl. ¶ 6. Mr. Schubert takes issue with my characterization of the PCFG's abundance trend as "stable and recently increasing," and suggests that NMFS should explain whether threats to the PCFG are increasing and whether the "stable" abundance estimates indicate a problem for the group. Schubert Decl. ¶ 91. To clarify, PCFG abundance estimates since the early 2000s have been relatively stable but have increased in 2013-2015 (an observation made by the authors of that study, who noted "the abundance estimates have been fairly stable since 2002 and recently increasing"). NMFS Ex. 3-33, at 11 (Calambokidis *et al.*

2017). That the PCFG abundance has been relatively stable over the past decade does not necessarily indicate a cause for concern. That is, no population, or feeding aggregation in the case of PCFG whales, can increase without limitation. Factors such as birth rate, mortality and survivorship, immigration, emigration, and density regulate population growth and can lead to stability in abundance as is seen for the PCFG.

15. My first declaration describes the 2012 NMFS Task Force review of genetic, photo-identification, tagging, and other studies indicating that ENP gray whales recruit into the PCFG partly due to internal recruitment (*e.g.*, calves coming to the PCFG area with PCFG mothers) and partly due to external recruitment (non-PCFG whales coming to the PCFG area and being sighted in one or more subsequent years). Weller Decl. ¶¶ 7, 17-18, 27; NMFS Ex. 3-2 (Weller *et al.* 2013). The best available evidence suggests that recruitment is fairly evenly split between these two sources, *i.e.*, around 50 percent internal recruits / 50 percent external recruits. Weller Decl. ¶ 27; NMFS Ex. 3-47 (Lang and Martien 2012). I do not agree with Mr. Schubert's assertion that growth of the PCFG is likely through internal recruitment. *See* Schubert Decl. ¶ 38 (citing AWI Ex. 24, Calambokidis and Perez 2017). The cited paper reviews photo-identification data and found that PCFG whales often migrate together, and that such behavior "raises the potential these animals associate on winter breeding grounds as well." AWI Ex. 24, at 2. It does not support a different conclusion from that reached by the NMFS Task Force that "recruitment is most likely about equal between internal (births) and external (immigration) recruitment." NMFS Ex. 3-2, at 44 (Weller *et al.* 2013).

16. Similarly, I do not agree with the statements in the declaration of Ms. Margaret Owens that PCFG whales are an internally recruited clan with significant genetic and behavioral differences from ENP gray whales. Owens Decl. ¶ 5. Although there is scientific evidence that

some PCFG whales learn to feed in the PCFG range as calves with their mothers (NMFS Ex. 3-37 (Frasier *et al.* 2011), NMFS Ex. 3-36 (Lang *et al.* 2011a)), the likelihood that a calf will return to feed in future years in subareas of that range where it has fed with its mother is unknown. *See* AWI Ex. 24 (Calambokidis and Perez 2017). Also, as stated above, the best available scientific evidence indicates that approximately half of PCFG whales are recruited internally and half through external recruitment. NMFS Ex. 3-2 (Weller *et al.* 2013). Lang and Martien (2012) (NMFS Ex. 3-47) concluded that the genetic evidence was most consistent with the theory that four non-PCFG ENP gray whales recruit into the group each year on average. I am not aware of any scientific evidence supporting Ms. Owens's assertion that externally recruited PCFG whales are less likely to be "successful" (which is not defined by Ms. Owens) within the PCFG range than internally recruited PCFG whales. *See* Owens Decl. ¶ 5.

17. Issue I.A.3(d)(ii) in the Final Hearing Agenda asks whether the PCFG is delineated into subgroups with distinct feeding areas, and whether PCFG whales randomly choose feeding areas or are internally or externally recruited into subgroups. Mr. Schubert asserts that there is a sub-population of PCFG whales that have historically shown high site fidelity to specific summer feeding areas, including the Makah U&A, and which would therefore be at risk from a tribal hunt. Schubert Decl. ¶ 97. As described in the 2015 DEIS[2] (page 3-139), the best scientific evidence available indicates that although some gray whales return to the same general feeding area in at least some later years, photo-identification data have demonstrated large-scale movements and variability in PCFG gray whale distribution and habitat use within season and between years. These movements and variability are likely due to shifts in prey

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[2] Per the regulations that govern the hearing in this matter, the 2015 DEIS will be introduced into evidence at the commencement of the hearing. *See* 50 C.F.R. § 228.16(b); Yates Decl. ¶ 12.

availability, the opportunistic and diverse nature of the species' feeding ecology, and the ability of gray whales to respond rapidly to changes in prey and to explore alternate feeding areas throughout their range. This flexibility, coupled with the location of the PCFG area in the midst of the migration route for the entire ENP herd, provides an obvious and natural mechanism for new whales to join the PCFG.

18. The Declaration of Ms. Margaret Owens asserts that certain ENP gray whales show fidelity to specific feeding sites within the PCFG range and/or break off, "in groups, to their own favorite feeding sites." Owens Decl. ¶ 4. This is an oversimplification of the gray whales' complex behavior. While the cited report by Calambokidis *et al*. (2015) does refer to "five PCFG feeding aggregations," the authors are referring to "biologically important areas" used by PCFG whales for feeding, not to specific individual whales that feed together in separate groups. *See* NMFS Ex. 3-88, at 1, 6-7 (Calambokidis *et al.* 2015). The paper does not identify any subgroupings of whales or indicate that individual whales intentionally select certain feeding areas, nor is there evidence that use of such areas evidences biologically meaningful sub-structure within the PCFG (*e.g.*, preferential mating between whales observed feeding in a particular area). It instead describes approximate areas where PCFG whales are regularly surveyed and documented feeding.

19. As noted in the paragraph above, the best available scientific evidence indicates that whales seen in the PCFG area exhibit a wide range of movements intra- and inter-annually. For example, Calambokidis et al. (2017) note that of the 143 whales seen in nine or more years from 1996 to 2015, none were seen exclusively in a single survey region, and over 67 percent were seen in at least four of the nine survey regions. *See* NMFS Ex. 3-33.

20. Ms. Owens's declaration also refers to "33 gray whales of Clallam County" that Ms. Owens asserts are faithful to the Makah Tribe's usual and accustomed fishing grounds (U&A). Owens Decl. ¶¶ 4, 5, 9. The reference to 33 whales "faithful to the Makah U&A" is incorrect and misleading. As explained in the 2015 DEIS (p. 3-155), that number does not refer to the same individual whales present within the Makah U&A year after year; it represents the average number of whales in a given year documented in the Makah U&A that have been identified and catalogued anywhere within the PCFG range. Those data, based on the photo-identification report by Calambokidis *et al*. (2014) (NMFS Ex. 3-78), show that the number of PCFG whales sighted in a given year in the Makah U&A between June 1 and November 30 has averaged 33 and ranged from 8 (in 2002) to 75 (in 2008). The 2015 DEIS states that "those numbers [33 for Makah U&A] do not represent the total numbers of whales that use each of these areas because not all whales using a region in a year are seen, not all whales return to the same region each year, and not all of the whales return to the PCFG region each year." 2015 DEIS at 3-147. The most recent report by Calambokidis *et al*. (2017) reports that the estimated average number of whales sighted within the Makah U&A in any one year from 1996 through 2015 is 37. NMFS Ex. 3-33, at 9, 27 (Calambokidis *et al.* 2017). It is reasonable to expect that this number will continue to increase, because photo-identification surveys regularly continue to document and catalog whales in the PCFG range, including within the Makah U&A (discovery curve).

21. Ms. Owens also asserts that there are only five known reproductive females belonging to the so-called "Makah U&A whales." Owens Decl. ¶ 12. As I explain above, there is no scientific information supporting substructure within the PCFG or indicating that only certain individual PCFG whales occur within the Makah U&A. The best scientific evidence

available indicates that approximately half of PCFG whales are female and half male. Ms. Owens defines “reproductive females” as whales who have been seen with calves and references a non-published exhibit/map that cites gray whale sighting data from Cascadia Research. Owens Decl. Attachment 2. There is no scientific basis for assuming that there are only five reproductive females using the Makah U&A, because only five have been seen with calves (according to her unpublished map). Also, it appears that the most recent data point used by Ms. Owens in her exhibit is from May 2002, which fails to incorporate the most recent 13 plus years of survey data maintained by Cascadia Research Collective. *See* NMFS Ex. 3-33 (Calambokidis *et al*. 2017).

22. Based on the information provided in my first declaration and for the reasons elaborated above, I do not consider it likely that the proposed waiver will cause localized depletion of PCFG whales, affect the distribution of PCFG whales within the Makah U&A, or affect PCFG abundance through impacts on reproductive females.

23. My first declaration describes my familiarity and experience with use of photo-identification techniques and the catalogs available for use in identifying WNP and PCFG whales. Weller Decl. ¶¶ 29-32, 37. Mr. Schubert asserts in his declaration that there is no way to distinguish between members of the ENP, PCFG, or WNP absent genetic testing. Schubert Decl. ¶ 19; *see also id.* ¶ 35 (stating that WNP whales cannot be distinguished from ENP or PCFG whales except through genetic testing). This assertion is not accurate. There are two possible methods for determining whether a gray whale is a WNP whale, a PCFG whale, or a non-PCFG whale of the ENP stock: (1) photo identification, or (2) genetic matching of a whale that was previously genetically sampled. It is not possible to use genetic material of an unknown

whale to determine to which group it belongs (that is, to do an "assignment test"). *See* NMFS Ex. 3-58 (Lang *et al*. 2010).

MIGRATORY MOVEMENTS

24. Issue 1.A.3(a) includes the question whether the ENP stock's migratory range should include the Okhotsk Sea. I understand that it is the position of the Makah Indian Tribe, based on the most plausible stock structure hypotheses considered by the IWC, that gray whales that feed in the WNP but also migrate to the ENP stock's range should be considered either a feeding aggregation ("Western Feeding Group," or WGF) of the "Eastern breeding stock" (EBS), or a mixed feeding group of whales from the EBS and whales from the "Western breeding stock" (that does not migrate to the ENP). As stated in my first declaration, a task force of NMFS experts examined the best available evidence regarding gray whale stock structure at a 2012 workshop and concluded that significant genetic differences and other information supported designating the WNP population as a separate stock under the MMPA. Weller Decl. ¶ 35; *see also* Bettridge Decl. ¶ 17. As I explain in more detail in paragraph 30 below, NMFS's recently-released 2018 SAR for the WNP stock continues to conclude that the whales that feed off Sakhalin Island in the Sea of Okhotsk Sea and off southeastern Kamchatka in the Bering Sea are part of the WNP gray whale stock under the MMPA, therefore NMFS does not identify the Okhotsk Sea as part of the ENP stock's migratory range.

25. Paragraphs 21 and 22 from Mr. Schubert's declaration assert that the timing of the ENP stock's southbound migration is changing due to loss of sea ice, such that calves are more often born in the open ocean during migration instead of the protected lagoons of the Pacific coast of Mexico, which is increasing threats to gray whale calves due to predation and energetic costs associated with surviving in colder water and to complete the migration to Mexico. Mr.

Schubert cites Rugh *et al.* (2001) (AWI Ex. 2), which was based on data collected between 1967-1999, wherein whale passage dates off two census points along the California coast were about seven days later post-1980 compared to pre-1980. It is questionable if this analysis, using available data from ~20-50 years ago, remains relevant today. Given that the ENP gray whale stock has grown to its highest level of abundance as of 2016, it does not appear that the change in migratory timing reported by Rugh *et al.* (2001) has had any lasting consequences in terms of population viability. Further, there are no direct data that I am aware of showing how water temperature affects energetic costs and survival of gray whale calves.

HEALTH AND STABILITY OF THE MARINE ECOSYSTEM

26. In my first declaration, I explain that the northern California Current ecosystem is the smallest marine ecosystem recognized in the scientific literature that contains the proposed hunt area. This ecosystem also corresponds with the seasonal range of the PCFG. Weller Decl. ¶ 68. Mr. Schubert asserts in several places throughout his declaration that NMFS must evaluate ecosystem effects at a smaller scale. *E.g.*, Schubert Decl. ¶¶ 47, 95-100. However, Mr. Schubert does not present any scientific information to support the assertion that a biologically or ecologically meaningful "ecosystem" exists within the Makah U&A that should be used as the area of analysis for purposes of the MMPA's policy of protecting the health and stability of marine ecosystems and the functioning of marine mammals within their ecosystems. I therefore disagree with Mr. Schubert's position.

27. Nevertheless, in preparing my first declaration, I considered whether effects from the proposed waiver could affect marine habitat at the smaller scales of the northern Washington Coast or the Makah U&A and concluded that any effects would be unlikely due to the nature of

the large-scale processes that affect those habitats and the limited nature of the proposed hunt. Weller Decl. ¶¶ 70-72.

28. Paragraph 95 of Mr. Schubert's declaration argues that gray whales can have a significant impact on their ecosystems, as prey and due to their bottom feeding behavior. Gray whales, most commonly mothers with their dependent calves, are sometimes attacked by killer whales and therefore can be considered to be prey. Much of this predation occurs during the northward migration and several particular areas are known to be hot spots for attacks, including: Monterey Bay, CA, Unimak Pass, AK, and off the Chukotka peninsula, Russian Federation. The portion of the PCFG range where the proposed hunt is to take place is not recognized as a similar hotspot. Despite the level of natural mortality attributable to killer whales, the eastern North Pacific population of gray whales has continued to undergo population growth or in the case of PCFG, population stability. With respect gray whale bottom feeding, it has been suggested that this behavior plays a role in ecological succession of benthic prey communities. However, periods of non-use of an area is of equal or perhaps greater significance with respect to recovery and maturing of the prey base. Given that the PCFG area undergoes periods of non-use, as well as periods of high use not only by PCFG whales but also by other whales migrating north, it is unlikely that any changes to the structuring of the ecosystem would result from the proposed hunt.

29. As noted by Mr. Schubert (paragraph 96), in NMFS's Proposed Rule and in paragraph 72 of my first declaration, we characterize the likely environmental effects of hunt-related activities as temporary and localized. Proposed Rule, 84 Fed. Reg. at 13,639, 13,642; Weller Decl. ¶ 72. Mr. Schubert suggests that use of the term "localized," indicates that NMFS did not sufficiently consider the possibility of effects at a local level. *See* Schubert Decl. ¶ 96.

To clarify, by use of the term "localized," I meant within proximity to where the stated hunt activities (*e.g.* boats, canoes, carcass towing) would occur. The area in which these activities would occur is finite in scale on a given day of hunting and therefore broader effects at a "local level" would not be expected.

WNP GRAY WHALE STOCK

30. As stated in Dr. Bettridge's second declaration, NMFS recently issued the 2018 SARs for the ENP and WNP gray whale stocks. Second Bettridge Decl. ¶ 4. The 2018 SAR includes a revised abundance estimate of 290 median, range of 271-311, for the WNP stock. The revised estimate is derived from a model incorporating a combined dataset of gray whales that generally occur off Sakhalin Island and off the southeastern Kamchatka peninsula of Russia. While the parameters of this modeling work have varied over time due to the ever-increasing scientific knowledge and the particular hypotheses being tested, based on an updated analyses of individual identification data including mother-calf pairs, satellite tag tracking of individuals, WNP-ENP migratory movements, and the results of paternity analysis and sex determination from genetic samples, Cooke *et al.* (2018) (NMFS Ex. 3-89) concluded that the gray whales summering off Sakhalin and southeastern Kamchatka may constitute a demographically self-contained unit where mating occurs at least preferentially, and possible exclusively. Using this combined unit of Sakhalin and Kamchatka whales together best fits the population assessment model used by Cooke *et al*. (2017) (NMFS Ex. 3-90) and differs from earlier assessments that were based only on those whales observed off Sakhalin.

31. My first declaration explains that the primary range of the WNP gray whale stock includes summer feeding areas off Sakhalin Island and southeastern Kamchatka, Russia, and migratory corridors along the WNP to Asia for some whales as well as along the ENP to Mexico,

but that at least 30 WNP whales have been documented within the range of the ENP stock during the winter/spring migration season. Weller Decl. ¶¶ 33-34. As Mr. Schubert states, a total of 54 individual WNP whales have been observed in the ENP range as of 2019. Schubert Decl. ¶ 32 (citing Urbán *et al*. 2019, NMFS Ex. 3-91). To clarify, this is a cumulative total of individuals spanning various data sources collected between 1995 and 2019.

32. Mr. Schubert asserts that the number of WNP whales crossing to the ENP range is increasing. Schubert Decl. ¶ 35. I disagree. The increased number of whales matched via photo identification is more likely the result of additional data and increased efforts to match whales between the WNP and ENP rather than an actual increase in the number of WNP whales migrating through the ENP range.

33. A recent analysis by Cooke *et al*. (2019) (NMFS Ex. 4-14), following an updated ENP-WNP photo-catalog matching exercise (Urbán *et al.* 2019) (NMFS Exhibit 3-91), reported that the number of whales undertaking the WNP to ENP migration is now, based on the best available data, less than Cooke previously estimated. Cooke (2015) (NMFS Ex. 4-11) estimated that 37-100 percent of whales identified off Sakhalin Island, Russia, made the cross-basin movement. Cooke *et al*. (2019) revised this estimate to 45-80 percent. NMFS Ex. 4-14, at 2, 5.

34. As noted in paragraph 24 above, I understand it is the position of the Makah Indian Tribe (Declarations of Jonathan Scordino and Dr. John Bickham) that gray whales that migrate from the WNP to the ENP should not be considered part of the WNP stock as recognized by NMFS under the MMPA. Nevertheless, Mr. Scordino's and Dr. Bickham's testimony agrees that these whales, given genetic differences from other whales within the ENP stock, should be considered a separate stock under the MMPA. They assert that questions remain about the status and stock identity of WNP gray whales. That is, some evidence is consistent with WNP gray

whales comprising a separate population while other information suggests gene flow with the ENP population. Given that several stock structure hypotheses are presently considered as plausible by the IWC and others, it is clear that the stock status of WNP gray whales remains scientifically uncertain. Therefore, it is not reasonable to rule out the possibility that any individual whale observed off Sakhalin and/or Kamchatka, regardless of breeding stock, might migrate to the ENP where it could be exposed to the Makah hunt. It is therefore my opinion that the analysis we undertook to evaluate the potential risk to the WNP stock, as currently defined by NMFS under the MMPA, from the proposed waiver is conservative and supported by the best scientific evidence available. *See* NMFS Ex. 4-8 (Moore and Weller 2018); NMFS Ex. 4-15 (Moore and Weller 2019).

35. As stated in my first declaration, if a WNP whale were subjected to non-lethal hunt activities (*e.g.*, approaches, training, and unsuccessful strike attempts), I would not expect the experience to lead to mortality, injury, or more than temporary disturbance to the affected animal. Weller Decl. ¶ 65. NMFS has evaluated the potential risk of hunters striking a WNP gray whale and included protective measures in the proposed regulations to minimize this risk. *See* NMFS Ex. 4-8 (Moore and Weller 2018); NMFS Ex. 4-15 (Moore and Weller 2019); Yates Decl. ¶¶ 63-39.

I declare, under penalty of perjury under the laws of the United States, that the foregoing is true and correct to the best of my knowledge, information, and belief.

David Weller

Digitally signed by David Weller
DN: cn=David Weller, o, ou,
email=dave.weller@noaa.gov, c=US
Date: 2019.08.06 11:02:06 -07'00'

Dr. David Weller

Dated: 6 August 2019

SECOND DECLARATION OF DR. DAVID WELLER
EXHIBIT LIST

3-85	Ronzón-Contreras et al. 2019	Ronzón-Contreras, F., S. Martínez-Aguilar, S.L. Swartz, E. Calderon-Yañez, and J. Urbán R. 2019. Gray whales' body condition in Laguna San Ignacio, SCS, Mexico during 2019 winter breeding season. Paper SC/68A/CMP/13 presented to the International Whaling Commission Scientific Committee.
3-86	Weller and Perryman 2019	Weller, D.W. and W.L. Perryman. 2019. Eastern North Pacific gray whale calf production estimates 1994-2018. Paper SC/68A/CMP/17 presented to the International Whaling Commission Scientific Committee.
3-87	IWC 2019	IWC 2019. Aboriginal subsistence whaling catches since 1995. Available online: https://iwc.int/table_aboriginalcite. Last accessed July 31, 2019.
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3-89	Cooke et al. 2018	Cooke, J.G., Taylor, B.L. Reeves, R. and Brownell Jr., R.L. 2018. Eschrichtius robustus (western subpopulation). The IUCN Red List of Threatened Species 2018.
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Gray whales’ body condition in Laguna San Ignacio, BCS, México, during 2019 winter breeding season

F. Ronzón-Contreras, S. Martínez-Aguilar, S.L. Swartz, E. Calderon-Yañez and J. Urbán R.

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GRAY WHALES' BODY CONDITION IN LAGUNA SAN IGNACIO, BCS, MEXICO DURING 2019 WINTER BREEDING SEASON

F. Ronzón-Contreras[1], S. Martínez-Aguilar[1], S.L. Swartz,[2], E. Calderon-Yañez[1], and J. Urbán R.[1]

[1] *Departamento de Ciencias Marinas y Costeras, Universidad Autónoma de Baja California Sur, La Paz, B.C.S., Mexico*

[2] *Laguna San Ignacio Ecosystem Science Program (LSIESP), Darnestown, MD, USA*

ABSTRACT

The Eastern North Pacific (ENP) gray whale (*Eschrichtius robustus*) population feeds during the summer around the Bering, Chukchi and Beaufort seas, and migrates to winter breeding and calving grounds along the Pacific coast of Baja California, in Mexico. Measurements of the whales' body condition upon arrival at the breeding grounds is an indicator of "health and reproductive condition," and indirectly is an indicator of the health of the environment. We photographed and evaluated the body condition of 569 gray whales in Laguna San Ignacio (LSI) in Baja California Sur in 2019. Photographs were sorted into two reproductive-sex categories: Females with calves, and Single whales (male or female without a calf). Condition was scored as "good", "fair", or "poor" using a method developed for the Western North Pacific (WNP) gray whales. In 2019 the proportion of single whales with "good condition" was 22.1%; "fair" 54.3% and "poor" 23.6%. The percent of "poor" body condition in 2019 is the highest observed in LSI in the last ten years. The proportion of females with calves with "good," "fair", and "poor" condition in 2019 were 50.0%, 50.0%, and 0%, respectively. The decrease of single whales in "good" condition during 2019 was not reflected in the percent of females with calves, but may be the result of a small sample of female-calf pairs photo-identified in 2019 (n=41), compared to the average of 226 pairs photo-identified each year from 2011 to 2017. We conclude that the body condition of all whales was probably similarly affected; however, comparison and correlation with environmental data from the feeding grounds is needed to understand the factors that contribute to the whales' body and reproductive condition.

Key words: gray whale, females with calves, single whales, body condition, Laguna San Ignacio.

INTRODUCTION

The long-term database for gray whale abundance and photographic-identification in Laguna San Ignacio (LSI) developed during the past 14 winters (2006-2019) by the Laguna San Ignacio Ecosystem Science Program (LSIESP) and Programa de Investigación de Mamíferos Marinos, Universidad Autónoma de Baja California Sur (PRIMMA-UABCS) facilitates the detection, and assessment of trends in abundance, distribution, and fitness of gray whales during the winter breeding season.

After the unusual range-wide mortality event of 1999-2000, some indicators of the whales' body condition and reproductive health have been evident in some years, including: a reduction of breeding females that resulted in lower calf production, as noted by LeBoeuf *et al.* (2000) and Urbán *et al.* (2003); fewer sightings of female-calf pairs in the breeding areas off Baja California's Pacific coast (Urbán *et al.* 2010); and the presence of whales with physical indications of nutritional stress, or "skinny whales".

During the 14-year post-mortality-event period, cohorts of young female gray whales would be increasing each year, maturing and beginning to reproduce successfully. We would then expect to see increasing numbers of females-with calves as these new breeders replace those that were lost during the mortality event (Swartz *et al,* 2012). The increase in the number of female-calf pairs observed in Laguna San Ignacio since 2011, supports this hypothesis (Urbán *et al.* 2011).

During the 2008 - 2011 period, the body condition of gray whales in Laguna San Ignacio was analyzed from photographic-identification (Photo-ID) images following the numerical scoring method developed for Western North Pacific (WNP) gray whales by Weller *et al*. (2002), and Bradford *et al.* (2012). The scores of "poor" body condition for single whales during this period ranged from 4.9% to 7.6%, while scores for females with calves ranged from 0% to 2.3%. While collection of Photo-ID data continued in LSI, condition analyses were suspended after the 2011 winter.

METHODS

Each winter during the gray whales' winter breeding and calving season in LSI, Photo-ID surveys are conducted from a 23-ft long, outboard-driven boat (Panga). Additional information collected with each whale sighting included: weather conditions, geographical position, and characteristics of the gray whale groups (*i.e.,* number of whales, and the presence of calves). Whales are photographed with digital SLR cameras (*e.g.,* Nikon D7100) equipped with 70-300 mm telephoto lenses. Efforts are made to photograph the head, scapula and flank of each whale.

Digital images are stored and archived in high resolution JPEG format, every individual whale is assigned an identification number (*e.g.,* 19-0001-D-LSI), and added to the Photo-ID catalog for LSI. The body condition of each individual whale is evaluated and assigned a numerical score using the methodology developed for WNP gray whales by Weller *et al.* (2002) and Bradford *et al.* (2012). A numerical score was assigned to the post cranial area, scapular region and the lateral flanks depending on their condition. The post cranial (head) could be assigned values from 1 to 3, with 3 indicating "good condition" and 1 when it had a visible "depression" indicating a "poorer" condition. The scapular region and the lateral flank were assigned values from 1 and 2, with 2 indicating "good condition" and 1 when a subdermal protrusion of the scapula or a depression along the dorsal aspect of the lateral flanks was apparent in the photographs (Brownell and Weller 2001). These scores were used to rank each whale's condition using the Bradford *et al.* (2012) body condition table (Table 1). Whales were sorted into groups as Females with calves, or single whales (males or females without a calf).

RESULTS

During the 2019 winter (mid-January to end of March), 47 days and 222.8 hours were spent conducting Photo-ID surveys in Laguna San Ignacio (10 days less than an average breeding season, due to the inclement weather conditions and the low number of whales in the lagoon at the end of the season (*Urbán et al.* 2019). In total 888 adult whales were photographed: 847 single whales; and 41 females with calves, which is the lowest number of female-calf pairs photo-identified in LSI since 2010 (Table 2).

Photographs suitable for condition evaluation were obtained for 569 individual whales: 529 single whales and 40 females with calves. Of these, 22.1% (n=117) of single whales and 50% (n=20) of females with calves were scored as having "good" body condition. "Fair" condition was represented by 54.3% (n=287) of single whales and 50% (n=20) of females with calves. Finally, 23.6% (n=125) of single whales and none of the females with calves had scores indicating "poor" condition, or as “skinny whales” (Table3).

It’s important to note that the percent of single whales with "poor" condition decreased as the winter breeding season progressed; at the beginning of the season (January 15 to February 15), there was a higher percentage of single whales with poor body condition 32.8%, (n= 57) compared to 19.2% (n=68) observed during the remainder of the season (February 15 to March 28 (Table 4).

Finally, after matching all the 2019 Photo-ID data from Laguna San Ignacio and the Bahía Magdalena complex to the south, 5 whales from the WNP gray whale population were identified among the ENP gray whales photographed; 2 whales were photographed in Laguna San Ignacio and 3 whales were photographed in the Bahía Magdalena region. Of these, 3 female whales were in "good" body condition, one male was in "fair" condition, and the condition of a whale of unknown sex could not be analyzed (Table 5).

DISCUSSION

During the years following the unusual mortality event of 1999-2000, some gray whales (mostly single whales without calves) exhibited indications of nutritional stress; these were "skinny" whales with post-cranial depressions, protruding scapulae, and concave rather than convex flanks. Analysis of the Photo-ID data obtained from 2008 to 2011 revealed that the percent of single whales with "poor" condition ranged from 4.9% (n=17) in 2011 to 7.6% (n=18) in 2009.

From 2012 to 2017, gray whales exhibiting "fair" to "poor" body condition were rarely encountered, and the analysis of gray whale body condition was suspended for whales photographed in LSI. However, beginning in 2018 whales with "fair" and "poor" body condition began to re-appear in LSI, so the analysis of body condition was resumed beginning in 2018. Unfortunately, the body condition of only 35% (n=207) of the single whales photographed could be evaluated in that year, due to the lack of photographs of their post-cranial and scapular regions. Of the 207 single whales evaluated in 2018, 43.5% (n=90) were in "good" condition, 48.3% (n=100) were in "fair" condition, and 8.2% (n=17) were in "poor" condition (Table 3).

The arrival of gray whales in LSI in 2019 was delayed approximately two-weeks compared with arrival times in the previous 10-years. The whales that did arrive during the last two weeks of January to the first two weeks of February included 32.8% (n=57) of "poor" condition whales, while only 19.2% (n=68) of the whales arriving later in the season from 16 February to 28 March exhibited "poor" condition" (Table 4). This suggests that the earlier arrivals at LSI were no able to obtain sufficient food during the previous summer to sustain a "good" or "fair" body condition.

The percent 26.3% (n=125) of single whales with "poor" condition in 2019 was the highest observed in LSI during the past 10-years, and while the condition of females with calves was "good" to "fair", their abundance in 2019 was the lowest recorded the period from 2011 to 2019 following the post-mortality event (Table 3). Additional analyses of Photo-ID data obtained in 2019 from Bahía Magdalena to the south of LSI is currently in progress.

The condition of females with calves observed in 2019 did not exhibit an increase in "poor" body condition similar to that seen with the single whales. However the "good" body condition of females with calves declined from 96.8% (n=30) in 2010 to 43.8% (n=35) by 2018, and was 50% (n=20) by 2019. Similarly, reproducing female whales with "fair" body condition ranged from a low of 3.2% (n=1) in 2010 to 53.8% (n=43) in 2018, and 50% (n=20) in 2019. Both the decline in "good" condition and the increase in "fair" condition for these female whales suggests these has been a trend for declining condition in breeding females over the past 2-years.

Gray whales feed primarily in the high latitudes of the North Pacific, and Arctic regions in summer where primary production rates are high, and their invertebrate prey are most abundant. In the fall they migrate south to mid-latitude breeding areas that do not support similar amounts of prey and where the whales do not feed. Thus, they must feed sufficiently during the summer months to develop sufficient body fat and blubber to make their annual southward migration, breed and birth their calves during the winter, and then make a return migration to the feeding ground the following spring. These migrations and winters between summer feeding are energetically costly, especially for breeding females that must feed sufficiently during the summer to maintain their own body condition while pregnant, birth their calf, and nurse that calf until weaned. In their classic monograph, Rice and Wolman (1971) reported a 30% weight loss between gray whales, including females, harvested during their fall southward migration to the breeding-calving grounds and those harvested during their spring northward migrations to the feeding grounds.

It is not unreasonable to suspect that if reproductively active females cannot obtain sufficient food during the summer, either because the sea ice conditions limit the time and areas available to feed during the summer (Perryman *et al*. 2002), and/or prey abundance is reduced or not available, reproductive females may not have sufficient energy reserves to successfully bring a calf to term and migrate into and out of the southern breeding and calving areas in Baja California, Mexico. Depending on the their energy stores coming off the summer feeding grounds, and the rate of depletion of their body fat and blubber, successful birthing and survival of calves, and the survival of the females becomes questionable during periods of limited resources.

If there is insufficient food and reduced energy stores for a pregnant female to bring a calf to term, birth and nurse that calf, an individual female whale's calving interval may be expected to increase from the typical 2-year reproductive cycle for gray whales with each year she is not able to reproduce. Support for such a reduction in reproduction in recent years comes from the analysis of Photo-ID records for LSI that identified 5 breeding females with regular 2-year calving intervals that were expected to have a calf in 2019, but they were observed without calves that year. Two additional females with previous 2-year calving intervals have increased breeding intervals of 3-years (Table 6).

Perhaps during the past decade, the ENP gray whale population has reached the current "carrying capacity" of its high-latitude feeding areas, and/or that the capacity for the marine environment to produce gray whale prey has changed. Recent fluctuations in ocean environment conditions associated with warmer-than-normal sea temperatures in the North Pacific/Gulf of Alaska may disrupt seasonal primary production during the summer months in the high latitudes where the gray whales feed (Belles 2016). This could impact and even reduce the availability of seasonal food that gray whales depend on during the summer to obtain sufficient energy to survive the winter and breed successfully. Recent observations of increasing "poor" condition gray whales and low calf production in the breeding and calving lagoons suggest that finding sufficient food is becoming a problem for the gray whales.

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Table 1. Body condition categories for gray whales (from *Bradford et al.*, 2012)
Scored as: (Post-cranial depression =1-3; Scapula =1-2; Flank =1-2)

Good—322, 321, 32X, 312, 31X, 3X2, 3X1, 3XX;
Fair—311, 222, 221, 22X, 212, 21X, 2X2, 2X1, 2XX;
Poor—211, 122, 121, 12X, 112, 111, 11X, 1X2, 1X1, 1XX;
Unknown—X22, X21, X2X, X12, X11, X1X, XX2, XX1, XXX.

Table 2. Number of females with calves photo-identified every year In Laguna San Ignacio, BCS, Mexico from 2010 to 2019.

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Effort (days)	58	55	64	57	66	67	56	59	59	47
No. Females with calves	37	196	233	190	209	287	249	218	86	41

Table 3. Numbers and percentages of gray whale base on their body condition for Laguna San Ignacio, BCS, Mexico (2008-2011 and 2018-2019)

Single whales/year	2008	2009	2010	2011	2018	2019
No. whales Photo-identified	249	588	718	424	597	847
No. whales categorized	89	236	433	347	207	529
Good Condition (%)	46 (51.7%)	119 (50.4%)	206 (47.6%)	221 (63.7%)	90 (43.5%)	117 (22.1%)
Fair Condition (%)	37 (41.6%)	99 (41.9%)	200 (46.2%)	109 (31.4%)	100 (48.3%)	287 (54.3%)
Poor Condition (%)	6 (6.7%)	18 (7.6%)	27 (6.2%)	17 (4.9%)	17 (8.2%)	125 (23.6%)
Females with calves						
No. whales Photo-identified	112	79	38	188	86	41
No. whales categorized	79	70	31	176	80	40
Good Condition (%)	52 (65.8%)	52 (74.3%)	30 (96.8%)	124 (70.5%)	35 (43.8%)	20 (50%)
Fair Condition (%)	27 (34.2%)	18 (25.7%)	1 (3.2%)	48 (27.3%)	43 (53.8%)	20 (50%)
Poor Condition (%)	0	0	0	4 (2.3%)	2(2.5%)	0

Table 4. Numbers and percentages of gray whales base on their body condition for Laguna San Ignacio, BCS, Mexico separated in two periods (Jan15-Feb15 and Feb 16-March 28).

Periods	15 Jan-15 Feb	16 Feb-28 Mar
No. whales Photo-identified	256	591
No. whales categorized	174	355
Good Condition	35 (20.1%)	82 (23.1%)
Fair Condition	82 (47.1%)	205 (57.7%)
Poor Condition	57 (32.8%)	68 (19.2%)

Table 5. Photographic identification recaptures between gray whales from Mexico (Laguna San Ignacio-LSI and Bahía Magdalena-BM areas) and Russia (Sakhalin Island region) in 2019, their sex and body condition.

Mexico ID (LSIESP/UABCS)	Sakhalin ID (Burdin / Weller)	Sex	Body condition
19-0466-D-LSI	68	Male	Fair
19-0905-D-LSI-M	29	Female	Good
19-0011-D-BM-M	38	Female	Good
19-0013-D-BM-M	1	Female	Good
19-0197-D-BM	181	Unknown	Unknown

Table 6. Female gray whales that had breeding intervals of two years, that were expected to have a calf, but did not have a calf in 2019, and female whales that used to have 2 years breeding intervals that reached to 3 years breeding interval. (Mc-Female with calf, S- single or without a calf, --- not seen during the year).

Id./year	2012	2013	2014	2015	2016	2017	2018	2019
13-0372-D-LSI-M	---	Mc	S	Mc	---	Mc	---	S
12-0033-D-LSI-M	Mc	---	---	Mc	---	Mc	S	S
12-0047-D-LSI-M	Mc	---	Mc	---	---	Mc	---	S
14-0052-D-LSI-M	---	---	Mc	---	---	S	S	S
12-0223-D-LSI-M	Mc	---	---	---	---	Mc	S	S
12-0043-D-LSI-M	Mc	---	Mc	---	Mc	---	---	Mc
12-0044-D-LSI-M	Mc	---	Mc	---	Mc	---	---	Mc

SC/68A/CMP/17

Eastern North Pacific gray whale calf production estimates 1994-2018

David W. Weller and Wayne L. Perryman

INTERNATIONAL
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Eastern North Pacific gray whale calf production estimates 1994-2018

DAVID W. WELLER AND WAYNE L. PERRYMAN

Southwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, La Jolla, California, USA

Contact e-mail: dave.weller@noaa.gov

ABSTRACT
Shore-based visual counts of eastern North Pacific gray whale calves during their northward migration were conducted between late March and early June each year from 1994-2018 off central California. Estimates of the number of northbound calves showed a high degree of inter-annual variability, ranging from a high of 1,528 in 2004 to a low of 254 in 2010. Calf production was consistently high (exceeding >1,000 calves annually) between 2012-2017, when more than 7,500 calves were estimated. The 2016 estimate of 1,351 calves was about 5% of the most recently reported total abundance of 26,960 (in 2016) for the eastern North Pacific population. In 2018, calf production declined to 867, a level similar to 2011 (858 calves).

KEYWORDS: GRAY WHALE; EASTERN NORTH PACIFIC; CALF PRODUCTION

INTRODUCTION

The majority of eastern North Pacific gray whales *(Eschrichtius robustus)* annually migrate southward from summer feeding grounds in the Pacific Arctic to wintering areas off Baja California, Mexico (Rice and Wolman 1971). Both the southward and northward migration is segregated, to a large extent, by age, sex and reproductive condition. During the northward migration, females with their calves of the year are the last to depart the Baja wintering areas. These mother-calf pairs are observed on the migration route between late March and late May and typically arrive to the summer feeding grounds sometime between May and June. Shore-based counts of northbound gray whale calves have been conducted off central California each spring from 1994 to 2018. This report presents an overview of results from this 25-year time series of estimates for eastern North Pacific gray whale calf production.

METHODS

Shore-based counts of northbound gray whale calves have been conducted from the Piedras Blancas Light Station (north of San Simeon, California) each spring from 1994 to 2018. Data collection methods and analytical techniques have remained consistent each year and follow those reported elsewhere (see Perryman *et al.* 2002; 2017). Briefly, counts were conducted by four observers, with two on effort at any one time, rotating through the following schedule: (a) 90-min on effort as the 'offshore' search area observer, (b) 90-min on effort as the 'inshore' search area observer, (c) 3-hr off effort. Weather permitting, this work was carried out for 12 hours per day; 6 days per week in 1994-2003 and 2005 and 5 days per week in 2004 and 2006-2018. Primary search effort was carried out with unaided eye but 7x50 and 25x150 binoculars were also used when needed.

Based on night/day migration rate data derived from thermal sensors (1994-1996) and aerial surveys (1994-1995) to determine offshore distribution (Perryman *et al.* 2002), it was assumed that: (a) the number of gray whale calves passing the survey site far enough offshore to be undetectable by visual observers was negligible, and (b) day and night passage rates were equivalent. Detection probabilities were also assumed to be the same across acceptable sighting conditions (see Reilly *et al.* 1983; Reilly 1992). To account for imperfect probability of detection of calves by the visual observers, estimates were corrected by the average detection probability obtained from seven consecutive years (1994-2000) of independent replicate counts (mean = 0.89; SE = 0.064).

Each day of survey effort was divided into four 3-hr periods and passage rates during these periods were calculated from the observed counts multiplied by the inverse of the detection function. To correct for periods when observers were not on watch (e.g. poor weather, night time, days off), we embedded the estimators in a finite population model that was stratified by week to account for varying passage rates (Cochran 1977). A Taylor series expansion (Seber 1982) was used to calculate the variance of the estimates.

RESULTS

Estimates of the number of northbound calves showed a high degree of inter-annual variability, ranging from a high of 1,528 in 2004 to a low of 254 in 2010. (Table 1). Calf production was consistently high (exceeding >1,000 calves annually) between 2012-2017 (Fig. 1), when more than 7,500 calves were estimated. The 2016 estimate of 1,351 calves was about 5% of the most recently reported total abundance of 26,960 (in 2016) for the eastern North Pacific population (Durban *et al*. 2017). In 2018, calf production declined to 867, a level similar to 2011 (858 calves) prior to the aforementioned higher levels recorded between 2012 and 2017.

DISCUSSION

During the 25-year time series reported here, estimates of gray whale calves displayed a high degree of inter-annual variability. Based on data from 1994 to 2000, Perryman *et al*. (2002) suggested that the reliance of female gray whales on stored fat resources during pregnancy combined with sea ice regulated access to food during the beginning of a feeding season may impact their ability to carry existing pregnancies to term. When these estimates were examined in the context of environmental data from the northern Bering Sea, a relationship was found between the timing of seasonal ice melt and estimates of northbound gray whale calves counted the following spring. In heavy ice years, when ice extends far to the south, the temporary lack of access to foraging areas appears to have a negative impact on calf production.

The particularly high calf production observed during the 2012-2017 period suggests that gray whales have been experiencing a period of favorable feeding conditions in the Arctic, possibly related to the combination of expanding ice-free habitat (Moore *et al*. 2014), increased primary production (Arrigo and Dijken 2015) and increased flow of nutrient-rich waters through the Bering Strait (Woodgate *et al*. 2012). This hypothesis is further supported by the recent increase in abundance (26,960 in 2016) of the eastern North Pacific gray whale population (Durban *et al*. 2017).

While the impacts of climate change in the Arctic environment are far from being understood, gray whale calf production and abundance may represent a ‘boom time’, at least in the short-term, for baleen whales in the Pacific Arctic region as has been suggested by Moore (2016).

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Table 1

Annual survey information and eastern North Pacific gray whale calf production estimates 1994-2018.

Year	Effort Hours	Calf Count	Calf Estimate	SE
1994	671	325	945	68.21
1995	610	194	619	37.19
1996	694	407	1146	70.67
1997	709	501	1431	82.02
1998	554	440	1388	94.84
1999	737	141	427	41.10
2000	704	96	279	34.79
2001	722	87	256	28.56
2002	711	302	842	78.60
2003	686	269	774	73.56
2004	562	456	1528	96.00
2005	669	343	945	86.90
2006	531	285	1020	103.30
2007	469	117	404	51.20
2008	498	171	553	53.11
2009	476	86	312	41.93
2010	487	71	254	33.94
2011	500	246	858	86.17
2012	435	330	1167	120.29
2013	483	311	1122	104.14
2014	529	429	1487	133.35
2015	522	404	1436	131.01
2016	436	367	1351	121.38
2017	406	267	1054	101.10
2018	468	243	867	82.37

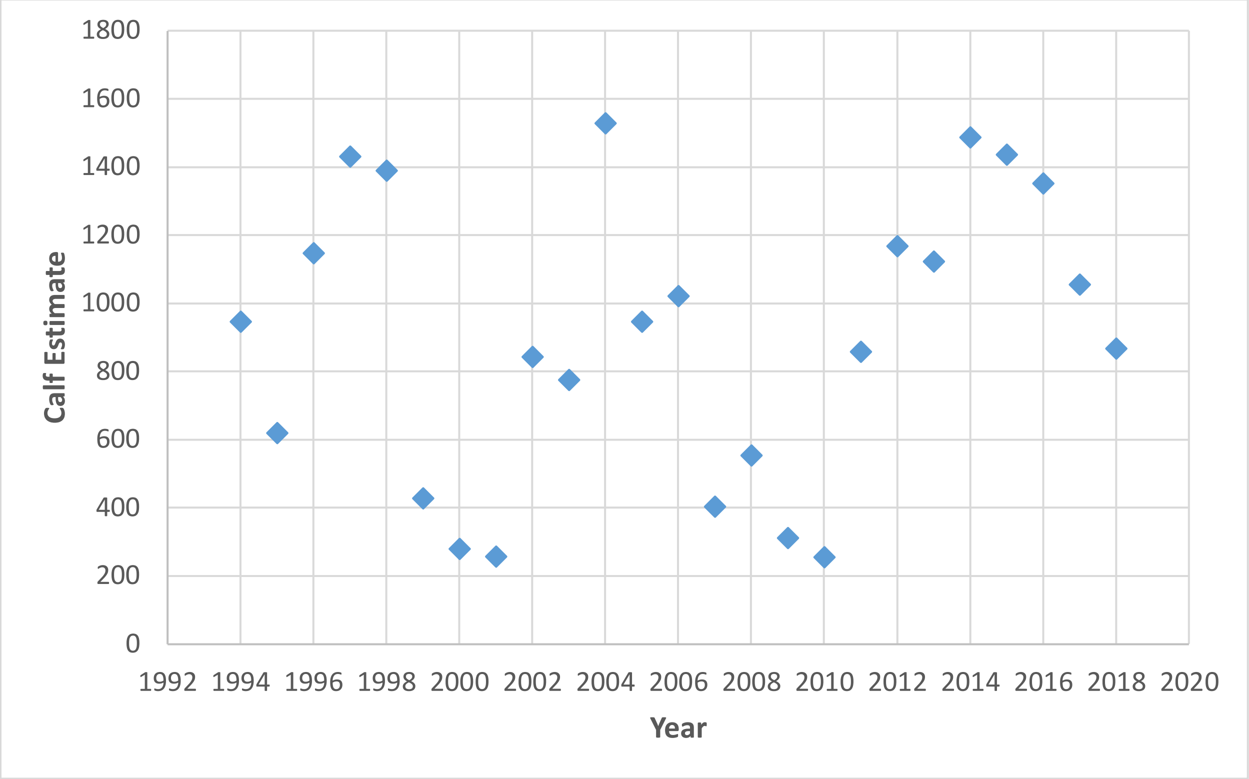

Fig. 1. Estimates of eastern North Pacific gray whale calf production 1994-2018.

INTERNATIONAL WHALING COMMISSION

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Catches Taken: ASW

Click HERE for a list of commercial catches taken under objection since the zero catch limits came into force
Click HERE for a list of aboriginal subsistence catches taken since the zero catch limits came into force
Click HERE for a list of special permit catches taken since the zero catch limits came into force

ABORIGINAL SUBSISTENCE WHALING CATCHES SINCE 1985

NOTE - these figures include all struck and lost whales

Nation	**Area**	**Fin**	**Humpback**	**Sei**	**Minke**	**Gray**	**Bowhead**	**Total**
Nation	**Area**	**Fin**	**Humpback**	**Sei**	**Minke**	**Gray**	**Bowhead**	**Total**
Nation	**Area**	**Fin**	**Humpback**	**Sei**	**Minke**	**Gray**	**Bowhead**	**Total**
Nation	**Area**	**Fin**	**Humpback**	**Sei**	**Minke**	**Gray**	**Bowhead**	**Total**
1985								
Denmark	W. Greenland	9	8	0	222	0	0	239
Denmark	E. Greenland	0	0	0	14	0	0	14
USSR	Chukotka	0	0	0	0	169	0	169
USA	Alaska	0	0	0	0	1	17	18
Total		9	8	0	236	170	17	440
1986								
Denmark	W. Greenland	9	0	0	145	0	0	154
Denmark	E. Greenland	0	0	0	2	0	0	2
St. Vincent & the Grenadines	W.Indies	0	2	0	0	0	0	2
USSR	Chukotka	0	0	0	0	169	0	169
USA	Alaska	0	0	0	0	2	28	30
Total		9	2	0	147	171	28	357
1987								
Denmark	W. Greenland	9	0	0	86	0	0	95
Denmark	E. Greenland	0	0	0	4	0	0	4
St. Vincent & the Grenadines	W.Indies	0	2	0	0	0	0	2
USSR	Chukotka	0	0	0	0	158	0	158
USA	Alaska	0	0	0	0	1	31	32
Total		9	2	0	90	159	31	291
1988								
Denmark	W. Greenland	9	1	0	109	0	0	119
Denmark	E. Greenland	0	0	0	10	0	0	10
St. Vincent & the Grenadines	W.Indies	0	1	0	0	0	0	1
USSR	Chukotka	0	0	0	0	150	0	150
USA	Alaska	0	0	0	0	1	29	30
Total		9	2	0	119	151	29	310
1989								
Denmark	W. Greenland	14	2	2	63	0	0	81
Denmark	E. Greenland	0	0	0	10	0	0	10
USSR	Chukotka	0	0	0	0	179	0	179
USA	Alaska	0	0	0	2	1	26	29
Total		14	2	2	75	180	26	299
1990								
Denmark	W. Greenland	19	1	0	89	0	0	109
Denmark	E. Greenland	0	0	0	6	0	0	6
USSR	Chukotka	0	0	0	0	162	0	162
USA	Alaska	0	0	0	0	0	44	44
Total		19	1	0	95	162	44	321
1991								
Denmark	W. Greenland	18	0	0	99	0	0	117
Denmark	E. Greenland	0	1	0	7	0	0	8
USSR	Chukotka	0	0	0	0	169	0	169

Nation	Area	Fin	Humpback	Sei	Minke	Gray	Bowhead	Total
USA	Alaska	0	0	0	0	0	47	47
Total		18	1	0	106	169	47	341
1992								
Denmark	W. Greenland	22	1	0	103	0	0	126
Denmark	E. Greenland	0	0	0	11	0	0	11
St. Vincent & the Grenadines	W.Indies	0	2	0	0	0	0	2
Russia	Chukotka	0	0	0	0	0	0	0
USA	Alaska	0	0	0	0	0	50	50
Total		22	3	0	114	0	50	189
1993								
Denmark	W. Greenland	14	0	0	107	0	0	121
Denmark	E. Greenland	0	0	0	9	0	0	9
St. Vincent & the Grenadines	W.Indies	0	2	0	0	0	0	2
USA	Alaska	0	0	0	0	0	52	52
Total		14	2	0	116	0	52	184
1994								
Denmark	W. Greenland	22	1	0	104	0	0	127
Denmark	E. Greenland	0	0	0	5	0	0	5
Russia	Chukotka	0	0	0	0	44	0	44
USA	Alaska	0	0	0	0	0	46	46
Total		22	1	0	109	44	46	222
1995								
Denmark	W. Greenland	12	0	0	153	0	0	165
Denmark	E. Greenland	0	0	0	9	0	0	9
Russia	Chukotka	0	0	0	0	90	0	90
USA	Alaska	0	0	0	0	2	57	59
Total		12	0	0	162	92	57	323
1996								
Denmark	W. Greenland	19	1	0	164	0	0	184
Denmark	E. Greenland	0	0	0	12	0	0	12
St. Vincent & the Grenadines	W.Indies	0	1	0	0	0	0	1
Russia	Chukotka	0	0	0	0	43	0	43
USA	Alaska	0	0	0	0	0	43	43
Total		19	2	0	176	43	43	282
1997								
Denmark	W. Greenland	13	0	0	148	0	0	161
Denmark	E. Greenland	0	0	0	14	0	0	14
Russia	Chukotka	0	0	0	0	79	0	79
USA	Alaska	0	0	0	0	0	66	66
Total		13	0	0	162	79	66	320
1998								
Denmark	W. Greenland	11	0	0	166	0	0	177
Denmark	E. Greenland	0	0	0	10	0	0	10
St. Vincent & the Grenadines	W.Indies	0	2	0	0	0	0	2
Russia	Chukotka	0	0	0	0	125	1	126
USA	Alaska	0	0	0	0	0	54	54
Total		11	2	0	176	125	55	369
1999								
Denmark	W. Greenland	9	2	0	170	0	0	181
Denmark	E. Greenland	0	0	0	15	0	0	15
St. Vincent & the Grenadines	W.Indies	0	2	0	0	0	0	2
Russia	Chukotka	0	0	0	0	123	1	124
USA	Alaska	0	0	0	0	0	47	47
USA	Washington State	0	0	0	0	1	0	1
Total		9	4	0	185	124	48	368
2000								
Denmark	W. Greenland	7	0	0	145	0	0	152
Denmark	E. Greenland	0	0	0	10	0	0	10
St. Vincent & the Grenadines*	W.Indies	0	2	0	0	0	0	3
Russia	Chukotka	0	0	0	0	115	1	116
USA	Alaska	0	0	0	0	0	47	47

WELLER **2 of 5** **NMFS Ex. 3-87**

Nation	Area	Fin	Humpback	Sei	Minke	Gray	Bowhead	Total
Total		7	2	0	155	115	48	328
* + 1 Bryde's whale taken illegally - reported as infraction								
2001								
Denmark	W. Greenland	8	2	0	139	0	0	149
Denmark	E. Greenland	0	0	0	17	0	0	17
St. Vincent & the Grenadines	W.Indies	0	2	0	0	0	0	2
Russia	Chukotka	0	0	0	0	112	1	113
USA	Alaska	0	0	0	0	0	75	75
Total		8	4	0	156	112	76	356
2002								
Denmark	W. Greenland	13	2	0	139	0	0	154
Denmark	E. Greenland	0	0	0	10	0	0	10
St. Vincent & the Grenadines	W.Indies	0	2	0	0	0	0	2
Russia	Chukotka	0	0	0	0	131	3	134
USA	Alaska	0	0	0	0	0	50	50
Total		13	4	0	149	131	53	350
2003								
Denmark	W. Greenland	9	1	0	185	0	0	195
Denmark	E. Greenland	0	0	0	14	0	0	14
St. Vincent & the Grenadines	W.Indies	0	1	0	0	0	0	1
Russia	Chukotka	0	0	0	0	128	3	131
USA	Alaska	0	0	0	0	0	41	41
Total		9	2	0	199	128	44	382
2004								
Denmark	W. Greenland	13	1	0	179	0	0	193
Denmark	E. Greenland	0	0	0	11	0	0	11
St. Vincent & the Grenadines	W.Indies	0	0	0	0	0	0	0
Russia	Chukotka	0	0	0	0	111	1	112
USA	Alaska	0	0	0	0	0	44	44
Total		13	1	0	190	111	45	360
2005								
Denmark	W. Greenland	13	0	0	176	0	0	189
Denmark	E. Greenland	0	0	0	4	0	0	4
St. Vincent & the Grenadines*	W.Indies	0	1	0	0	0	0	2
Russia	Chukotka	0	0	0	0	124	2	126
USA	Alaska	0	0	0	0	0	68	68
Total		13	1	0	180	124	70	389
* + 1 Bryde's whale taken illegally - reported as infraction								
2006								
Denmark	W. Greenland	10	1	1	181	0	0	193
Denmark	E. Greenland	1	0	0	3	0	0	4
St. Vincent & the Grenadines	W.Indies	0	1	0	0	0	0	1
Russia	Chukotka	0	0	0	0	134	3	137
USA	Alaska	0	0	0	0	0	39	39
Total		11	2	1	184	134	42	374
2007								
Denmark	W. Greenland	12	0	0	167	0	0	179
Denmark	E. Greenland	0	0	0	2	0	0	2
St. Vincent & the Grenadines	W.Indies	0	1	0	0	0	0	1
Russia	Chukotka	0	0	0	0	131	0	131
USA	Alaska	0	0	0	0	0	63	63
USA	Washington State	0	0	0	0	1	0	1
Total		12	1	0	169	132	63	377
2008								
Denmark	W. Greenland	14	0	0	153	0	0	167
Denmark	E. Greenland	0	0	0	1	0	0	1
St. Vincent & the Grenadines	W.Indies	0	2	0	0	0	0	2
Russia	Chukotka	0	0	0	0	130	2	132

Nation	Area	Fin	Humpback	Sei	Minke	Gray	Bowhead	Total
USA	Alaska	0	0	0	0	0	50	50
Total		14	2	0	154	130	52	352
2009								
Denmark	W. Greenland	10	0	0	164	0	3	177
Denmark	E. Greenland	0	0	0	4	0	0	4
St. Vincent & the Grenadines	W.Indies	0	1	0	0	0	0	1
Russia	Chukotka	0	0	0	0	116	0	116
USA	Alaska	0	0	0	0	0	38	38
Total		10	1	0	168	116	41	336
2010								
Denmark	W. Greenland	6	9	0	187	0	3	205
Denmark	E. Greenland	0	0	0	9	0	0	9
St. Vincent & the Grenadines	W.Indies	0	3	0	0	0	0	3
Russia	Chukotka	0	0	0	0	118	2	120
USA	Alaska	0	0	0	0	0	71	71
Total		6	12	0	196	118	76	408
2011								
Denmark	W. Greenland	5	8	0	179	0	1	193
Denmark	E. Greenland	0	0	0	10	0	0	10
St. Vincent & the Grenadines	W.Indies	0	2	0	0	0	0	2
Russia	Chukotka	0	0	0	0	128	0	128
USA	Alaska	0	0	0	0	0	51	51
Total		5	10	0	189	128	52	384
2012								
Denmark	W. Greenland	5	10	0	148	0	0	163
Denmark	E. Greenland	0	0	0	4	0	0	4
St. Vincent & the Grenadines	W.Indies	0	2	0	0	0	0	2
Russia	Chukotka	0	0	0	0	143	0	143
USA	Alaska	0	0	0	0	0	69	69
Total		5	12	0	152	143	69	381
2013								
Denmark	W. Greenland	9	8	0	175	0	0	192
Denmark	E. Greenland	0	0	0	6	0	0	6
St. Vincent & the Grenadines	W.Indies	0	4	0	0	0	0	4
Russia	Chukotka	0	0	0	0	127	1	128
USA	Alaska	0	0	0	0	0	57	57
Total		9	12	0	181	127	58	387
2014								
Denmark	W. Greenland	12	7	0	146	0	0	165
Denmark	E. Greenland	0	0	0	11	0	0	11
St. Vincent & the Grenadines	W.Indies	0	2	0	0	0	0	2
Russia	Chukotka	0	0	0	0	124	0	124
USA	Alaska	0	0	0	0	0	53	53
Total		12	9	0	157	124	53	355
2015								
Denmark	W. Greenland	12	6	0	133	0	1	152
Denmark	E. Greenland	0	0	0	6	0	0	6
St. Vincent & the Grenadines	W.Indies	0	1	0	0	0	0	1
Russia	Chukotka	0	0	0	0	125	0	125
USA	Alaska	0	0	0	0	0	49	49
Total		12	7	0	139	125	50	333
2016								
Denmark	W. Greenland	9	5	0	148	0	0	162
Denmark	E. Greenland	0	0	0	15	0	0	15
St. Vincent & the Grenadines*	W.Indies	0	0	0	0	0	0	0
Russia	Chukotka	0	0	0	0	120	2	122
USA	Alaska	0	1#	0	2#	0	59	62

Nation	Area	Fin	Humpback	Sei	Minke	Gray	Bowhead	Total
Total		9	6	0	165	120	61	361
* No catch in 2016								
# Unauthorized take								
2017								
Denmark	W. Greenland	8	2	0	133	0	0	143
Denmark	E. Greenland	0	0	0	10	0	0	10
St. Vincent & the Grenadines	W.Indies	0	1	0	0	0	0	1
Russia	Chukotka	0	0	0	0	119	1	120
USA	Alaska	0	0	0	0	1#	57	58
Total		8	3	0	143	120	58	332
# Unauthorized take								
Overall total		**385**	**123**	**3**	**5,094**	**3,907**	**1,650**	**11,164**

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4. Biologically Important Areas for Selected Cetaceans Within U.S. Waters – West Coast Region

John Calambokidis,[1] Gretchen H. Steiger,[1] Corrie Curtice,[2] Jolie Harrison,[3]
Megan C. Ferguson,[4] Elizabeth Becker,[5] Monica DeAngelis,[6] and Sofie M. Van Parijs[7]

[1]*Cascadia Research, Olympia, WA 98501, USA*
E-mail: Calambokidis@CascadiaResearch.org
[2]*Marine Geospatial Ecology Lab, Duke University, Beaufort, NC 28516, USA*
[3] *National Marine Fisheries Service, Office of Protected Resources, Silver Spring, MD 20910, USA*
[4]*National Marine Mammal Laboratory, Alaska Fisheries Science Center,*
National Marine Fisheries Service, NOAA, Seattle, WA 98115, USA
[5]*Southwest Fisheries Science Center, Marine Mammal and Turtle Division, Santa Cruz, CA 95060, USA*
[6]*NOAA Fisheries West Coast Region, Long Beach, CA 90802, USA*
[7]*Passive Acoustic Research Group, Northeast Fisheries Science Center, Woods Hole, MA 02543, USA*

Abstract

In this review, we combine existing published and unpublished information along with expert judgment to identify and support the delineation of 28 Biologically Important Areas (BIAs) in U.S. waters along the West Coast for blue whales, gray whales, humpback whales, and harbor porpoises. BIAs for blue whales and humpback whales are based on high concentration areas of feeding animals observed from small boat surveys, ship surveys, and opportunistic sources. These BIAs compare favorably to broader habitat-based density models. BIAs for gray whales are based on their migratory corridor as they transit between primary feeding areas located in northern latitudes and breeding areas off Mexico. Additional gray whale BIAs are defined for the primary feeding areas of a smaller resident population. Two small and resident population BIAs defined for harbor porpoises located off California encompass the populations' primary areas of use. The size of the individual BIAs ranged from approximately 171 to 138,000 km^2. The BIAs for feeding blue, gray, and humpback whales represent relatively small portions of the overall West Coast area (< 5%) but encompass a large majority (77 to 89%) of the thousands of sightings documented and evaluated for each species. We also evaluate and discuss potential feeding BIAs for fin whales, but none are delineated due to limited or conflicting information. The intent of identifying BIAs is to synthesize existing biological information in a transparent format that is easily accessible to scientists, managers, policymakers, and the public for use during the planning and design phase of anthropogenic activities for which U.S. statutes require the characterization and minimization of impacts on marine mammals. To maintain their utility, West Coast region BIAs should be re-evaluated and revised, if necessary, as new information becomes available.

Key Words: feeding area, migratory corridor, resident population, anthropogenic sound, species distribution, U.S. West Coast, North Pacific Ocean

Introduction

This review document coalesces existing published and unpublished information to define Biologically Important Areas (BIAs) in U.S. waters of the West Coast region (shoreward of the offshore boundary of the U.S. Exclusive Economic Zone [EEZ]) for cetacean species that meet the criteria for feeding areas, migratory corridors, and small and resident populations defined in Table 1.2 of Ferguson et al. (2015b) within this issue. A comprehensive overview of the BIA delineation process; its caveats (Table 1.4), strengths, and limitations; and its relationship to international assessments also can be found in Ferguson et al. Table 1.3 provides a summary of all BIAs identified, including region, species, BIA type, and total area (in km^2). A summary also can be found at http://cetsound.noaa.gov/important. Table 1.1 defines all abbreviations used in this special issue. Metadata tables that concisely detail the type and quantity of information used to define many of these BIAs are available as an online supplement. Our intent is to delineate BIAs by synthesizing information that is not publicly available from existing sources, is only partially represented through peer-reviewed publications, or is not evident in habitat-based density (HD) models. The goal of identifying BIAs is to synthesize existing biological information in a transparent format that is easily accessible to scientists, managers, policymakers, and the public for use during the planning and design phase of anthropogenic activities for which U.S. statutes require the characterization and minimization of impacts on marine mammals.

Within the West Coast region, three species—blue whale (*Balaenoptera musculus*), gray whale (*Eschrichtius robustus*), and humpback whale (*Megaptera novaeangliae*)—were evaluated and found to meet the criteria for feeding or migratory corridor BIAs. Fin whale (*B. physalus*) feeding BIAs are discussed, but no BIAs were defined due to limited or conflicting information. Small and resident population BIAs were created for harbor porpoises (*Phocoena phocoena*). BIAs for reproductive areas were not evaluated in this initial exercise but should be considered in the future. Although none of the focal species included in this chapter have dedicated reproductive areas within U.S. waters, some are found with calves and, therefore, might warrant designating BIAs for reproductive areas. Other species found in this region, including minke whale (*B. acutorostrata*), killer whale (*Orcinus orca*), beaked whales (Ziphiidae), and sperm whale (*Physeter macrocephalus*), were not evaluated during this initial BIA exercise; these species should be evaluated in future efforts to create or revise BIAs for cetaceans in this region.

The feeding BIA boundaries for the U.S. West Coast were based on two considerations: (1) direct observation of feeding or surfacing patterns and associated species strongly suggestive of feeding (and in some cases documented with archival tag data), and (2) presence of concentrations and repeat sightings of animals in multiple years in an area and a time of year where feeding is known to occur. The area boundaries were based on expert judgment, outlining areas of high sighting concentrations from multiple years. The heterogeneity in survey effort across the West Coast region was subjectively factored in to decrease the degree to which results were biased by areas searched, although allocating greater survey effort in areas where sightings had been documented in the past could also introduce bias. In addition, bathymetric features were considered in defining the BIAs when sightings were associated with a specific habitat, but the BIAs were restricted to the areas where the highest concentrations of sightings were documented in multiple years. The exact BIA boundaries for feeding blue, humpback, and gray whales were initially drawn to encompass sighting concentrations documented in multiple years and then processed in *ArcGIS* (ESRI, Redlands, CA, USA), using the Buffer tool applied to the original polygon with a 5-km buffer distance for blue and humpback whales (with a 1 km from shore exclusion) and a 3-km buffer distance for gray whales (excluding any direct overlap with shoreline).

We compared the BIAs determined here with the mean predicted densities from the HD models generated from the Southwest Fisheries Science Center's line-transect data collected since the 1990s (Becker et al., 2012a; Forney et al., 2012), the results of which are available to view on the CetMap website (http://cetsound.noaa.gov/cetsound). In those models, functional relationships between cetacean density and a variety of static and dynamic habitat variables were derived from the multi-year data and subsequently used to estimate two types of parameters: (1) annual densities that take into account each year's oceanic conditions and (2) multi-year average densities (and variation therein) within the study area (Becker et al., 2012a). The data used to delineate the BIAs were predominantly based on coastal (< 50 nmi offshore), nonsystematic small boat surveys conducted to maximize encounters with target species (i.e., blue, fin, humpback, and gray whales) for photo-identification and tagging studies. In contrast, the HD models were based on systematic line-transect survey effort conducted from large ships at 3- to 5-y intervals in summer and fall that extended out to 300 nmi offshore. Due to their broad geographic area, coverage in each year is a course with lines spaced about 80 nmi apart. The two datasets provide complementary information on the occurrence of blue, fin, and humpback whales: the small boat surveys were better able to resolve nearshore, fine-scale patterns of occurrence, whereas the HD models provided a systematic assessment of broad-scale patterns of occurrence throughout nearshore and offshore waters. We identify where the results of the BIA exercise and the HD models are concordant, complementary, or subject to differing potential biases. It is our hope that this overview will aid the reader in gaining an understanding of the strengths, limitations, and combined implications of the information presented herein.

Biologically Important Areas in the West Coast Region

*Blue Whale (*Balaenoptera musculus*)*

General—The blue whale, the largest of all animals, is an endangered species of baleen whale that feeds almost exclusively on krill. With the advent of modern whaling ships, blue whales became a primary target of modern commercial whalers. Worldwide populations were reduced in the 20th century from over 200,000 to well under

10,000 individuals, with most of those killed from the southern oceans (Gambell, 1976, 1979). Blue whales in the North Pacific Ocean are thought to consist of at least a western/central and an eastern population based on distribution and vocalizations, although historically there may have been as many as five populations in the North Pacific Ocean (National Marine Fisheries Service [NMFS], 1998). The eastern North Pacific blue whales are now known to range from the Costa Rica Dome to the Gulf of Alaska (Calambokidis et al., 2009a, 2009b, 2009c).

Since the 1970s, large concentrations of blue whales have been documented feeding off California each summer and fall (Calambokidis et al., 1990). Relatively low numbers of blue whales were taken by whalers off the U.S. West Coast (Rice, 1963, 1974), so it was initially unclear how the animals feeding off the U.S. West Coast were related to those from the primary areas where they had been taken farther north (NMFS, 1998). Shifts in blue whale distribution that occurred since the late 1990s, including documented movements of blue whales from California northward to areas off British Columbia and Alaska, have shown that blue whales inhabit a broad and shifting feeding area throughout the eastern North Pacific (Calambokidis et al., 2009a). These changes in blue whale distribution appear related to decadal oceanographic variations because the timing coincided with shifts in the Pacific Decadal Oscillation (Calambokidis et al., 2009a).

Unlike other baleen whale species in the eastern North Pacific whose populations have increased, such as fin, humpback, and gray whales, blue whales have not shown signs of recovery from whaling over the last 20 y. Blue whale population size from capture-recapture of photo-identified individuals has stayed relatively unchanged at around 2,000 since the early 1990s (Calambokidis & Barlow, 2004, 2013), and average abundance of animals from line-transect surveys off the U.S. West Coast has declined from close to 2,000 in the 1990s to 500 to 800 in the 2000s (Barlow & Forney, 2007; Barlow, 2010). These two methodologies provided different measures of abundance: data from line-transect surveys estimated the number of animals in the region during the survey period, whereas the photo-identification data provided estimates of the total population size (Calambokidis & Barlow, 2004). Part of the reason for the divergence in the estimates from capture-recapture and line-transect density appears to be the switch in distribution related to oceanographic conditions and related prey abundance mentioned above. The most recent stock assessment report (Carretta et al., 2013) reports blue whale abundance for the Eastern North Pacific Stock to be 2,497 (CV = 0.24) based on the capture-recapture of photographically identified whales from 2005 to 2008 (Calambokidis et al., 2009a), although new estimates using an alternate and more promising capture-recapture model have indicated an estimate closer to 1,500 based on data through 2011 (Calambokidis & Barlow, 2013).

Feeding Area BIAs—Blue whales are not evenly distributed along the West Coast; rather, they are found in aggregations, especially on the continental shelf edge (Croll et al., 2005; Keiper et al., 2011), with greater tendency to aggregate off California than Oregon and Washington. Based on 9,054 visual sightings of 17,178 blue whales, primarily from small boat surveys conducted from 1986 to 2011 by Cascadia Research (www.cascadiaresearch.org) and collaborators along the U.S. West Coast, nine common feeding areas of high blue whale concentration have been identified (Table 4.1; Figure 4.1). Additionally, feeding by blue whales on krill has also been documented in eight of the nine BIAs using

Table 4.1. Blue whale (*Balaenoptera musculus*) BIAs with map references (see Figure 4.1), primary months, area (km^2), number of sightings, and number of years for which the sightings have been documented

Map ref #	BIA name	Primary occurrence	Area (km^2)	# of sightings	# years of sightings
1	Point Arena to Fort Bragg	Aug-Nov	1,419	170	4
2	Gulf of the Farallones	July-Nov	5,243	1,565	24
3	Monterey Bay to Pescadero	July-Oct	2,378	801	16
4	Point Conception/Arguello	June-Oct	1,743	151	10
5	Santa Barbara Channel and San Miguel	June-Oct	1,981	3,117	18
6	Santa Monica Bay to Long Beach	June-Oct	1,187	764	5
7	San Nicolas Island	June-Oct	427	105	5
8	Tanner-Cortez Bank	June-Oct	1,076	52	5
9	San Diego	June-Oct	984	443	10
	Total blue whale BIA areas and sightings		16,438	7,168	
	Total EEZ area and sightings		820,809	8,244	
	Percentages		2%	87%	

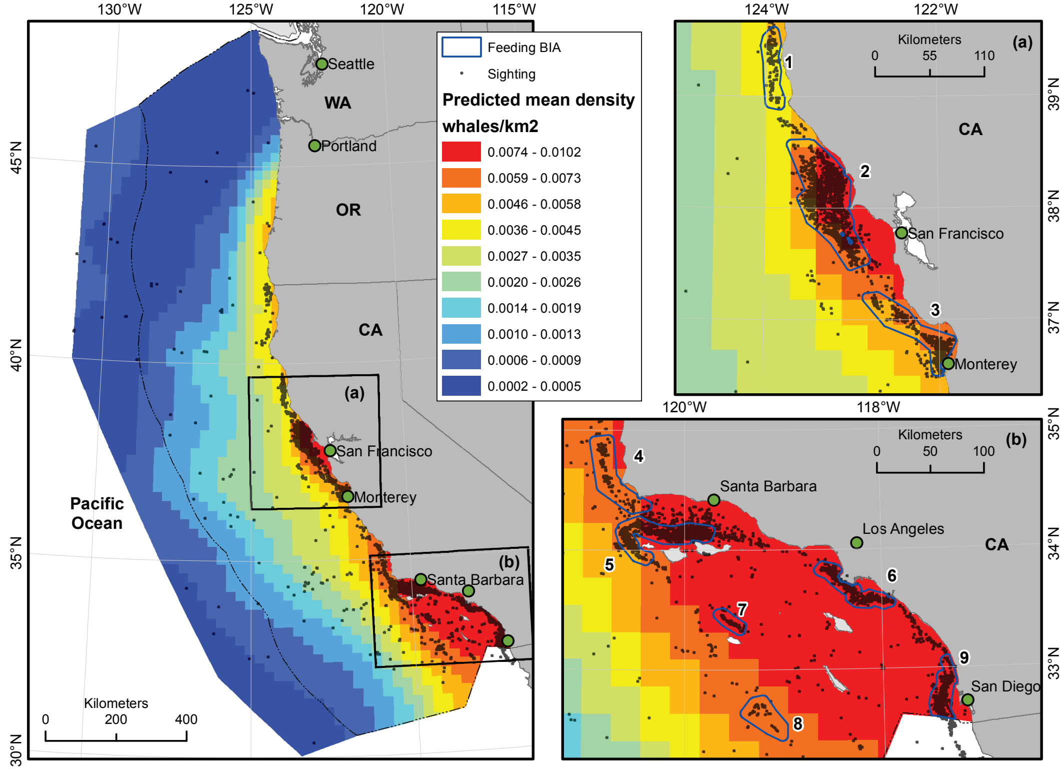

Figure 4.1. Nine blue whale (*Balaenoptera musculus*) Biologically Important Areas (BIAs), overlaid with all sightings and predicted mean densities of blue whales from habitat-based density (HD) models generated from Southwest Fisheries Science Center ship surveys (see Becker et al., 2012a). Panels a and b show more detail for the areas where the BIAs are located. The BIAs are (from north to south) (1) Point Arena to Fort Bragg, August-November; (2) Gulf of the Farallones, July-November; (3) Monterey Bay to Pescadero, July-October; (4) Point Conception/Arguello, June-October; (5) Santa Barbara Channel and San Miguel, June-October; (6) Santa Monica Bay to Long Beach, June-October; (7) San Nicholas Island, June-October; (8) Tanner-Cortez Bank, June-October; and (9) San Diego, June-October (see Table 4.1 for details).

suction-cup attached multi-sensor archival tags (Calambokidis et al., 2008b; Goldbogen et al., 2011, 2013; Friedlaender et al., 2014; Cascadia Research, unpub. data). Six of these areas are in or near the Southern California Bight.

Feeding BIAs for blue whales may extend farther north and for longer time periods than we currently are able to delineate. Despite limited effort in winter, two of the three known blue whale sightings off Washington in the last 50 y have been in December and January; one of these, made in December 2011, consisted of at least five blue whales with other unidentified whales (Cascadia Research, unpub. data, 2011; see also Figure 4.1). Satellite-tag data from blue whales also show animals that were thought to be feeding offshore of Washington in the winter (Bailey et al., 2010; Irvine et al., 2014). Unlike many other mysticete whales, blue whales appear to continue feeding through their winter breeding season, both in northern latitudes and in productive offshore lower latitude areas (Calambokidis et al., 2009c; Bailey et al., 2010).

Of the nine blue whale BIAs identified here, six overlap with areas of highest density identified in the HD model and the rest falling within areas of moderately high mean density (Figure 4.1). The areas of agreement occur in two regions: (1) the Southern California Bight, which represents the largest area of high density in the HD models and also is where a majority of the BIAs we identified occur; and (2) the Gulf of the Farallones where the BIA we identify (encompassing the area north including Cordell Bank and waters west of Bodega Bay) and where the HD model also predicts a high-density area. The BIAs are more centered along areas near the shelf edge as opposed to the mean density maps that show highest densities continuing all the way to shore, reflecting the HD models' lack of resolution at finer spatial scales. The three BIAs not shown in the HD model as areas of highest mean density do agree with predicted areas of moderately high density and also encompass areas predicted to have highest densities in some of the annual HD models. These three BIAs include the following:

1. An area along the shelf edge from Point Arena north to Fort Bragg, which is located farther north than any of the highest density areas from the mean HD models but is predicted to be a high-density area in some of the annual models
2. The Monterey Bay area north to Pescadero Point, which borders areas of highest mean density and which also is predicted to be a high-density area in some of the annual HD models
3. An area near Tanner and Cortez Banks where we have seen large blue whale concentrations on a number of surveys despite our low effort in this region

The six BIAs that we identified in the Southern California Bight represent only a fraction of the total area within the bight that the HD models predict to have high densities of blue whales. Our BIAs represent 2% of U.S. waters in the West Coast region but encompass 87% of the sightings we document within U.S. waters. While there is some evidence of annual variation in blue whale occurrence in both sighting locations and in the annual HD models (Figure 4.2), the areas identified represent those with the more consistent occurrence year to year.

*Gray Whale (*Eschrichtius robustus*)*

General—Gray whales were historically distributed in both the North Pacific and North Atlantic Oceans, although only the populations in the North Pacific Ocean remain today. In the North Pacific Ocean, two primary populations have been recognized: (1) an eastern (ENP) and (2) a western (WNP) population. More recently, the distinction between these two populations has been debated due to evidence that gray whales from the western feeding area are coming to breeding areas in the eastern North Pacific (Weller et al., 2012). These data suggest that animals from both eastern and western feeding areas migrate along the U.S. West Coast. Additionally, there is recent genetic evidence supporting the existence of a more distinct local subpopulation of ENP gray whales

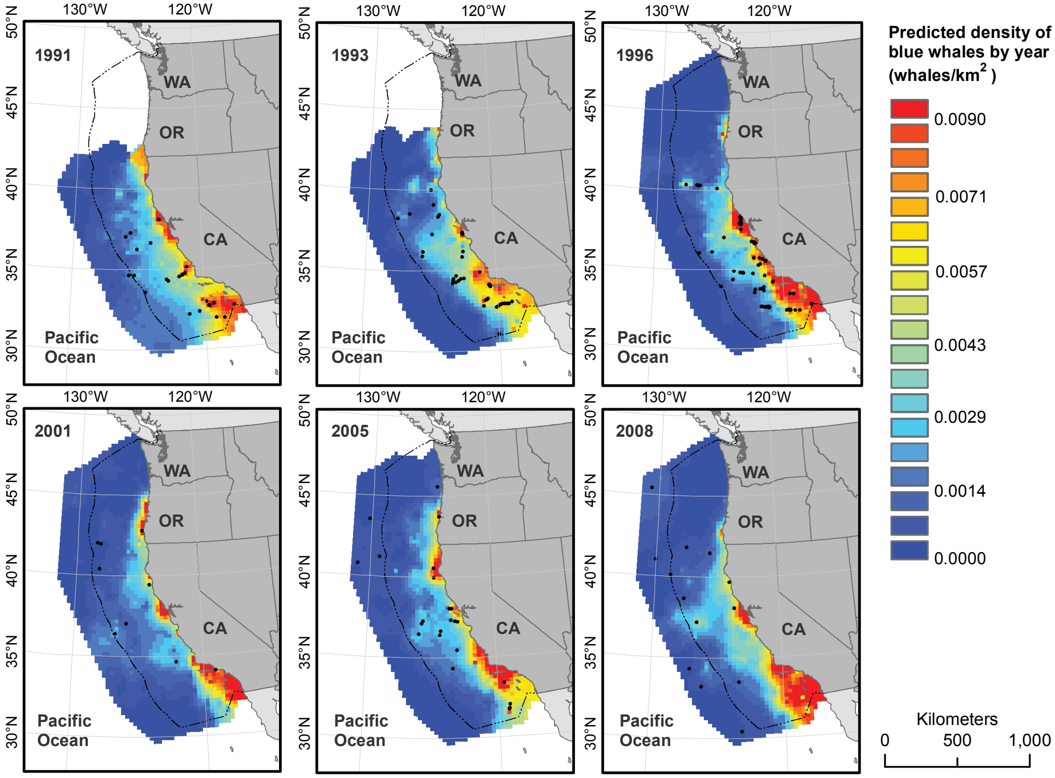

Figure 4.2. Predicted mean densities and sightings (black dots) of blue whales from HD models generated from Southwest Fisheries Science Center ship surveys (see Becker et al., 2012a) for individual years; U.S. EEZ boundary (Pacific Coast) is also shown.

called the Pacific Coast Feeding Group (PCFG) (Frasier et al., 2011; Weller et al., 2012; Lang et al., 2014). The PCFG is a trans-boundary subgroup shared by the U.S. and Canada, and PCFG whales are observed almost year-round, though primarily from spring to fall. During the migration, PCFG whales are intermixed with the larger overall ENP population, but from June to November, they are the only gray whales within the region between northern California and northern Vancouver Island (from 41° N to 52° N) (Calambokidis et al., 2002, 2010, 2014; International Whaling Commission [IWC], 2011c). PCFG gray whales are also occasionally seen in waters farther north during summer and autumn, including off Kodiak Island, Alaska (Gosho et al., 2011). The primary feeding areas for ENP gray whales are thought to be in the Bering and Beaufort Seas, while WNP gray whales are thought to feed primarily near Sakhalin Island, Russia, in the Okhotsk Sea. Therefore, proposed feeding BIAs in this region focus on the feeding PCFG gray whales.

Gray whales in the PCFG likely mate with animals from the ENP population. Although earlier work had not revealed significant genetic differences between PCFG and ENP gray whales (Ramakrishnan et al., 2001; Steeves et al., 2001), a later study of mitochondrial DNA (mtDNA) haplotypes (classification of maternally inherited mtDNA) using a larger sample size found significant differences between gray whales that were part of the PCFG and those from the overall ENP population (Frasier et al., 2011). This information is considered sufficient to represent the PCFG gray whales separately for the BIA exercise. Currently, PCFG whales are not treated as a distinct stock in the NMFS stock assessment reports, but this may change in the future based on the recently published genetic information mentioned above.

Photo-identification studies from 1998 through 2012 conducted between northern California and northern British Columbia estimate that the PCFG comprises approximately 200 animals (Calambokidis et al., 2002, 2010, 2014) compared to the population of close to 20,000 gray whales for the overall eastern North Pacific. The photo-identification data suggest that the range of at least some of the PCFG whales exceeds the pre-defined 41°N to 52°N boundaries that have previously been used in abundance estimates.

Feeding Area BIAs—Information from nonsystematic, visual boat-based surveys (4,907 sightings of 8,556 animals from 1991 to 2011) and tagging data collected by Cascadia Research (www.cascadiaresearch.org) and other collaborators (see Calambokidis et al., 2004, 2010, 2014; Moore et al., 2007) support the existence of five PCFG feeding aggregations within the West Coast region (Figure 4.3; Table 4.2).

Additionally, we designate a BIA in northern Puget Sound, around the south end of Whidbey and Camano Islands. Gray whales come to this area for 2 to 3 mo in the spring (typically beginning in March) to feed, but then generally leave the area before 1 June and, therefore, are not treated as PCFG gray whales (Calambokidis et al., 1992, 2002). While this area is not used by a large number of individuals, the same animals have been documented returning to this relatively small area for over 20 y, and it may, therefore, be important for this group (Calambokidis et al., 2014).

Most of the PCFG feed and are found in coastal nearshore waters, and our BIAs correspondingly are close to shore. Our BIAs encompass a relatively small portion of U.S. waters (0.2%) but contain 77% of the sightings we document. A dense aggregation of feeding gray whales was seen 20 to 25 km off the Washington coast in 2007 (Oleson et al., 2009), but it is unclear if this is a consistent feeding area, so it is not included as a BIA.

Migration—Gray whales migrate annually between their winter breeding grounds in the

Table 4.2. Gray whale (*Eschrichtius robustus*) BIAs with map references (see Figure 4.3), primary months, area (km^2), number of sightings, and number of years for which the sightings have been documented

Map ref #	BIA name	Primary occurrence	Area (km^2)	# of sightings	# years of sightings
1	Northern Puget Sound	March-May	326	263	15
2	Northwest Washington	May-Nov	515	744	14
3	Grays Harbor area, Washington	April-Nov	298	183	17
4	Depoe Bay, Oregon	June-Nov	199	92	9
5	Cape Blanco & Orford Reef, Oregon	June-Nov	171	126	9
6	Point St. George, California	June-Nov	418	110	10
	Total PCFG gray whale BIA areas and sightings		1,927	1,518	
	Total EEZ area and sightings		820,809	1,968	
	Percentages		0.2%	77.1%	

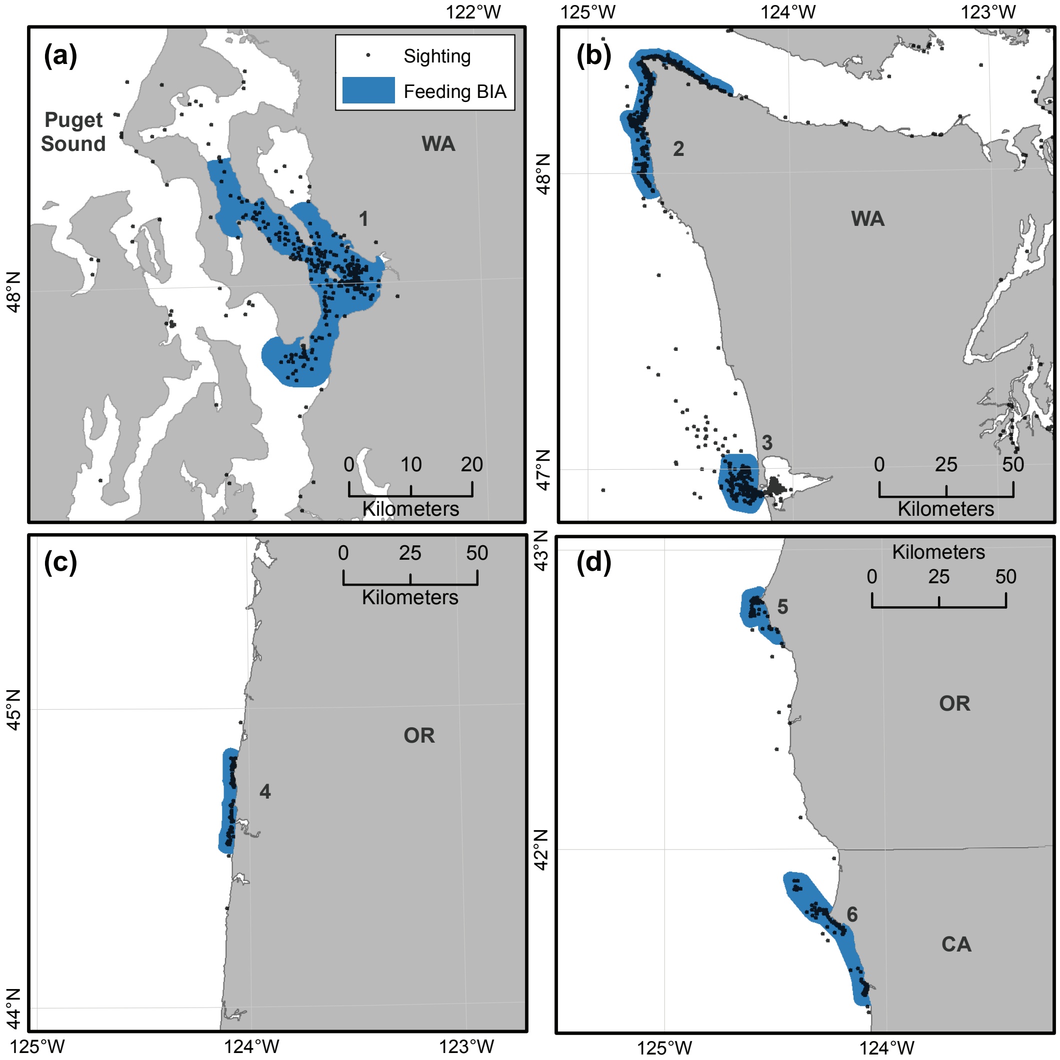

Figure 4.3. Six gray whale (*Eschrichtius robustus*) feeding BIAs shown in four panels a, b, c, and d that span the West Coast region from Washington to California. The BIAs are, from north to south, (1) Northern Puget Sound, March-May; (2) Northwestern Washington, May-November; (3) Grays Harbor, April-November; (4) Depoe Bay, June-November; (5) Cape Blanco & Orford Reef, June-November; and (6) Point St. George, June-November (see Table 4.2 for details). Also shown are sightings primarily from small boat surveys for photographic identification.

lagoons of Baja California, Mexico, and their summer feeding grounds in North Pacific and Arctic waters. This migration is comprised of ENP, PCFG, and at least some of the gray whales that feed in the western North Pacific (Perryman & Lynn, 2002; Shelden et al., 2004; Weller et al., 2012). The spatial and temporal parameters of the gray whale migratory corridor that is found nearshore along the U.S. West Coast are relatively well defined based on tagging studies, dedicated line-transect ship and aerial surveys for marine mammals, land-based counts, infrared technology to investigate nighttime passage rate, "coupled" aerial- and land-based visual surveys, and observations from whale-watching operations and recreational and commercial fishermen (Daily et al., 1993; Rugh et al., 2001, 2006; Mate & Urbán-Ramirez, 2003).

The gray whale migration along the U.S. West Coast (Figure 4.4; Table S4.1) can be loosely categorized into three phases (Rugh et al., 2001, 2006). The Southbound Phase includes all age classes as they migrate to the lagoons in Mexico (October-March, peaking in December-March).

Northbound Phase A consists mainly of adults and juveniles that lead the beginning of the northbound migration (late January-July, peaking in April-July). Cow-calf pairs generally begin their northward migration later (March-July) and are referred to as Northbound Phase B. The three phases are not always distinct, and the sea ice cover in the Bering Sea may influence migration dates (Perryman & Lynn, 2002). Historical gray whale land-based counts suggest that the migration rate (number of individuals/d) begins with a rapid spike, followed by moderate numbers over a few weeks before slowly tapering off (Rugh et al., 2006). The migration corridors used by most gray whales are within 10 km of the U.S. West Coast. The following breakdown by phase of distance from shore was used to define the three BIAs for the gray whale migration in this region based on the detailed information highlighted above and substantiated by expert judgment (Mate & Perryman, pers. comm., 2011):

1. Southbound Phase – 10 km
2. Northbound Phase A – 8 km
3. Northbound Phase B – 5 km

Some gray whales may take a migration path farther offshore, so an additional potential presence buffer extending 47 km from the coastline was added to the BIAs. Although gray whales typically tightly follow the coastline near the mainland, they have been observed taking a more direct route across larger bodies of water in California (Rice & Wolman, 1971; Mate & Urbán-Ramirez, 2003). Particularly during the northbound migration, gray whales with calves migrate closer inside the bay than adults and juveniles. In the Southern California Bight, migrating gray whales may deviate farther from the mainland as some are routinely seen near the Channel Islands (Daily et al., 1993).

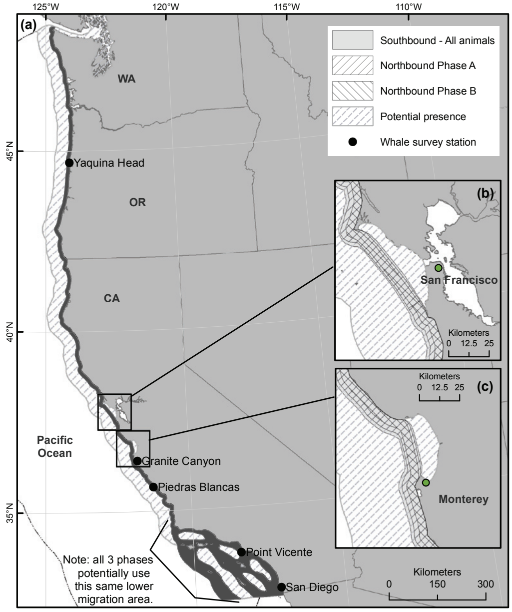

Figure 4.4. BIAs for the three phases (Southbound, Northbound Phase A, and Northbound Phase B) and for the potential presence area of the gray whale migratory corridor (a) along the West Coast of the U.S. from California to Washington, (b) keeping just outside of San Francisco Bay, and (c) keeping just outside of Monterey Bay; substantiated through vessel-, aerial-, and land-based survey data, satellite-tag data, and expert judgment.

*Humpback Whale (*Megaptera novaeangliae*)*

General—Humpback whales occur widely in the world's oceans and, although they remain endangered from hunting during the modern era of commercial whaling, many populations have made strong recoveries in the last 50 y (Calambokidis & Barlow, 2004; Barlow et al., 2011). In the North Pacific Ocean, humpback whales tend to alternate between winter breeding areas, including those in the western North Pacific Ocean, Hawai'i, Mexico, and Central America, and more coastal feeding areas in spring, summer, and fall that range from California, north into Alaskan waters, and west to waters off Russia (Calambokidis et al., 2001, 2008a). Both photo-identification and genetic data indicate that, in the North Pacific Ocean, humpback whales remain loyal to specific feeding and wintering areas, although their migrations between these areas reveal a mixed stock structure (Calambokidis et al., 2008a; Barlow et al., 2011; Baker et al., 2013).

Humpback whales are most abundant off the U.S. West Coast from spring through fall, with most migrating to low-latitude areas located primarily off Mexico and Central America in winter (Calambokidis et al., 2000). However, sightings and passive acoustic detections off the U.S. West Coast in winter and spring indicate a portion of the population can be in northern waters even in winter (Forney & Barlow, 1998; Oleson et al., 2009). There are also indications of seasonal shifts in occurrence both up and down the coast as well as inshore and offshore. During small boat surveys taken off the Washington coast in 2004 through 2008, humpback whales were seen farther offshore (along the shelf edge) and in lower densities in winter and spring than during the remainder of the year (Oleson et al., 2009).

There is little interchange between the humpback whale feeding aggregation off California/southern Oregon and the feeding aggregation off Washington/

southern British Columbia (Calambokidis et al., 1996, 2000, 2001, 2004, 2008a); this apparent segregation is not represented in the population units currently being considered by NMFS in the stock assessment reports. Genetic (mtDNA) studies have confirmed the distinctness of these Washington/British Columbia animals (Baker et al., 2008), and their abundance has been roughly estimated at about 200 animals in 2004-2005 (Calambokidis et al., 2008a).

Humpback whales that feed off the U.S. West Coast migrate primarily to wintering grounds off mainland Mexico and Central America (Calambokidis et al., 2000). The proportion of humpback whales going to different breeding grounds varies by latitude along the U.S. West Coast, with the highest proportions migrating to Central America from southern California feeding areas, in contrast to whales that feed in areas farther north that tend to migrate to areas off Mexico (Calambokidis et al., 2000, 2008a; Rasmussen et al., 2011). Humpback whales wintering off Central America have significant differences in mtDNA haplotypes from other North Pacific wintering areas, including mainland Mexico (Baker et al., 2008). The Central American wintering ground is inhabited by the smallest number of whales that occur in the North Pacific wintering grounds, consisting of just a few hundred whales (Calambokidis et al., 2008a; Rasmussen et al., 2011).

Feeding Area BIAs—Based on 11,757 visual sightings of 27,224 humpback whales, primarily from small boat surveys conducted from 1986 to 2011 by Cascadia Research (www.cascadiaresearch.org) and collaborators along the U.S. West Coast, seven areas where humpback whales are commonly sighted feeding in high concentrations have been identified (Figure 4.5; Table 4.3).

Humpback whale distribution on feeding areas off California, Oregon, and Washington is clumped and concentrated in coastal waters from the continental shelf to the shelf edge. HD models built on broad-scale line-transect survey data (extending 300 nmi offshore) capture coast-wide habitat relationships (Becker et al., 2012b). Effort-corrected sighting rates from coastal photo-identification surveys (1991 to 2010; Calambokidis et al., 2009b) off central California reveal high concentrations of humpback whales along the continental shelf edge, with densities generally decreasing inshore of those areas (Keiper et al., 2011). Humpback whales have also been documented feeding on both krill and small fish in three of the BIAs off California based on data from suction-cup attached multisensor archival tags (Goldbogen et al., 2008; Cascadia Research, unpub. data). Localized coastal boat-based photo-identification surveys conducted in the West Coast region by Cascadia Research reveal a high degree of variation in some areas of humpback whale concentration across years, whereas other areas appear to be used fairly consistently (Calambokidis et al., 2009b). Inter-annual variations are apparent in the annual HD models (Figure 4.6).

Of the seven BIAs identified for humpback whales, by far the largest encompasses the broad area extending south from west of Bodega Bay to and including Monterey Bay and encompassing Cordell Bank and the Gulf of the Farallones. This region agreed closely with the single region of highest density in the mean HD model (Figure 4.6). Another broad area of agreement between our BIA delineations and the mean HD model is the absence of BIAs south of the northern Channel Islands, where the HD model similarly showed mean densities declining. While the BIA off northern Washington appeared as a moderately high-density area in the mean HD model, the

Table 4.3. Humpback whale (*Megaptera novaeangliae*) BIAs with map references (see Figure 4.5), primary months, area (km^2), number of sightings, and number of years for which the sightings have been documented

Map ref #	BIA name	Primary occurrence	Area (km^2)	# of sightings	# years of sightings
1	Northern Washington	May-Nov	3,393	298	17
2	Stonewall and Heceta Bank	May-Nov	2,573	62	7
3	Point St. George	July-Nov	1,233	283	12
4	Fort Bragg to Point Arena	July-Nov	1,591	184	8
5	Gulf of the Farallones–Monterey Bay	July-Nov	9,761	5,196	25
6	Morro Bay to Point Sal	April-Nov	1,908	472	14
7	Santa Barbara Channel–San Miguel	March-Sept	2,639	2,250	18
	Total humpback whale BIA areas and sightings		23,098	8,745	
	Total EEZ area and sightings		820,809	9,850	
	Percentages		3%	89%	

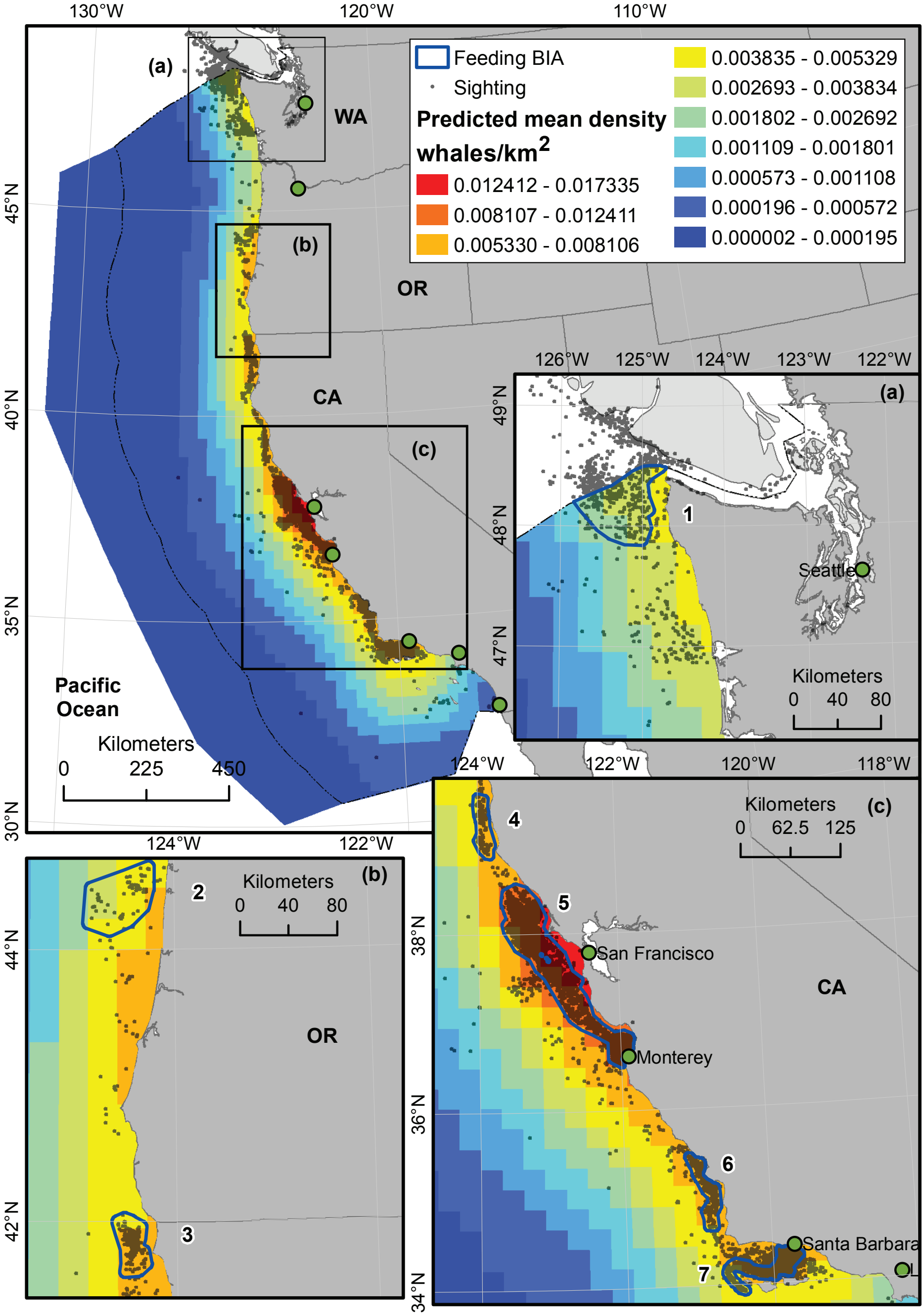

Figure 4.5. Seven humpback whale (*Megaptera novaeangliae*) feeding BIAs overlaid with all sightings and predicted mean densities of humpback whales from HD models generated from Southwest Fisheries Science Center ship surveys (see Becker et al., 2012a). Panels a, b, and c show more detail in the areas where the BIAs are located. The BIAs are (from north to south) (1) Northern Washington, May-November; (2) Stonewall and Heceta Bank, May-November; (3) Point St. George, July-November; (4) Fort Bragg to Point Arena, July-November; (5) Gulf of the Farallones–Monterey Bay, July-November; (6) Morro Bay to Point Sal, April-November; and (7) Santa Barbara Channel–San Miguel, March-September (see Table 4.3 for details).

annual HD model results for 2001 and 2008 (2 of the 3 y this region was covered) showed high densities in this area (Figure 4.6). This represented the area used by a smaller feeding aggregation of humpback whales that is distinct from those feeding off California and Oregon (Calambokidis et al., 1996, 2001, 2004), and it meets the criteria of a feeding BIA. The BIA located west and southwest of San Miguel Island, although not in the highest density area in the HD model, is an area of high density in some of the annual HD model predictions. These annual predictions agree with our observations that, similar to blue whales in this region, it is an area inhabited intermittently by some of the highest concentrations of humpback whales that have been observed in southern California.

The seven BIAs for humpback whales represented only 3% of U.S. waters in the West Coast region, but the areas we identified encompassed 89% of the sightings documented. Along with the good agreement with the areas identified by the HD model, these BIAs effectively identify the most critical areas for humpback whales.

*Harbor Porpoise (*Phocoena phocoena*) Small and Resident Populations*

Harbor porpoises in the northeastern Pacific Ocean range from Point Conception, California, through waters of British Columbia, and around the coast of Alaska to Point Barrow. They inhabit both coastal and inland waters, and are known to be particularly sensitive to anthropogenic impacts such as bycatch in fisheries and disturbance by vessel traffic or underwater noise. BIAs for this species are also designated for populations in the East Coast region (see LaBrecque et al., 2015, in this issue).

Several lines of evidence indicate segregation of separate harbor porpoise populations within the West Coast region. Early work showed regional differences in pollutant residues indicating that harbor porpoises do not move extensively along the U.S. West Coast (Calambokidis & Barlow, 1991). Based on more recent genetic studies and aerial surveys along the U.S. West Coast (Chivers et al., 2002, 2007; Carretta et al., 2009), NOAA Fisheries recognizes six distinct harbor porpoise populations in this region. Two of these populations (the Northern California/Southern Oregon

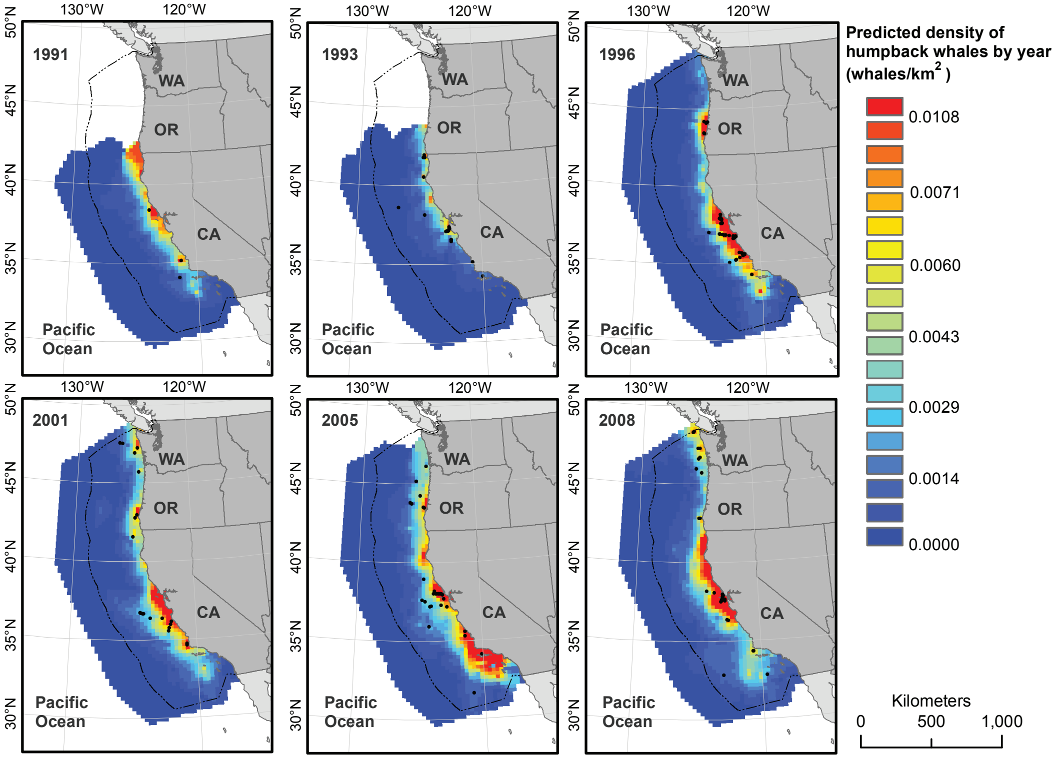

Figure 4.6. Predicted mean densities and sightings (black dots) of humpback whales from HD models generated from Southwest Fisheries Science Center ship surveys (see Becker et al., 2012a) for individual years; U.S. EEZ boundary (Pacific Coast) is also shown.

Stock and the Northern Oregon/Washington Coast Stock) number in the tens of thousands of animals. The San Francisco/Russian River Stock and the Washington Inland Waters Stock are estimated at 9,189 (Carretta et al., 2009) and 10,682 animals (Laake, unpub. data, as cited in Carretta et al., 2013), respectively. The remaining two populations are located along the coast of California near Morro Bay and Monterey Bay. Due to their relatively small abundance estimates of just a few thousand animals (see below) and restricted geographic ranges, the Morro Bay Stock and the Monterey Bay Stock meet CetMap's definition of a small and resident population, and BIAs were created for each stock (Figure 4.7). Stock boundaries were delineated based on (1) molecular genetic differences (Chivers et al., 2002), (2) differences in pollutant concentrations (Calambokidis & Barlow, 1991), and (3) density minima observed from aerial surveys (Forney et al., 1991; Forney, 1995, 1999; Carretta et al., 2009). All populations are described in the *U.S. Pacific Marine Mammal Stock Assessments* (Carretta et al., 2013).

Harbor porpoises are found primarily in waters shallower than about 200 m and are most abundant from shore to about the 92 m (50-fathom) isobath (Barlow, 1988; Forney et al., 1991; Carretta et al., 2001, 2009). Since 1999, aerial surveys off California have included coverage of lower density areas to provide a more complete abundance estimate, extending offshore to the 200-m isobath, or a minimum distance from shore of 10 nmi south of Point Sur and 15 nmi north of Point Sur. Off Oregon and Washington, where the shelf extends farther offshore, abundance has been estimated based on aerial surveys extending offshore to about the 200-m isobath (Laake, unpub. data, as cited in Carretta et al., 2013).

Morro Bay Small Resident Population—The southernmost population, called the Morro Bay Stock, extends from Point Conception to Point Sur and from land to the 200-m isobath (Figure 4.7; Table S4.2). The most recent aerial surveys (2002 to 2007), conducted by the Southwest Fisheries Science Center (NMFS/NOAA), yielded an abundance estimate of 2,044 animals for this population (Carretta et al., 2009). Aerial surveys have consistently indicated a core area of higher density near the center of the population's range between Point Arguello and Point Estero, with density decreasing toward the edges of the range (Forney et al., 1991; Forney, 1995, 1999; Carretta et al., 2009). The small core range of this small and resident harbor porpoise population makes this population particularly vulnerable to anthropogenic impacts.

Monterey Bay Small and Resident Population—The small and resident Monterey Bay population of harbor porpoises ranges from just south of Point Sur to Pigeon Point and out to the 200-m isobath (Figure 4.7; Table S4.3). The most recent aerial surveys (2002 to 2007) yielded an abundance estimate of 1,492 animals for this population (Carretta et al., 2009). The greatest densities are generally found in the northern portions of Monterey Bay (Forney et al., 1991; Forney, 1995). The small geographic range makes this population particularly vulnerable to anthropogenic impacts.

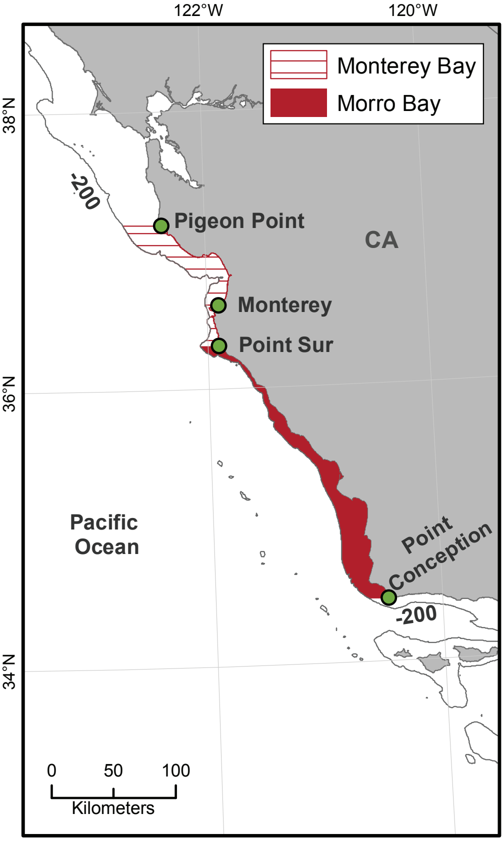

Figure 4.7. Two harbor porpoise (*Phocoena phocoena*) small and resident BIAs (Morro Bay and Monterey Bay) in California, substantiated through aerial survey data, genetic analyses, and expert judgment. Also shown is the 200-m isobath.

Additional Evaluation

Fin whales (*Balaenoptera physalus*), the second largest of all the whales, are considered endangered under the U.S. Endangered Species Act (ESA) and occur widely in the world's oceans (NMFS, 2010). Along with blue whales, they were heavily hunted in the 20th century during the modern era of commercial whaling. The population structure of fin whales is not well understood in most areas, including the North Pacific Ocean. They occur in both nearshore and pelagic waters, and they feed on both krill and fish.

A number of factors complicate our understanding of fin whales in the North Pacific Ocean, primarily because of uncertainties in their stock structure and movements along the U.S. West

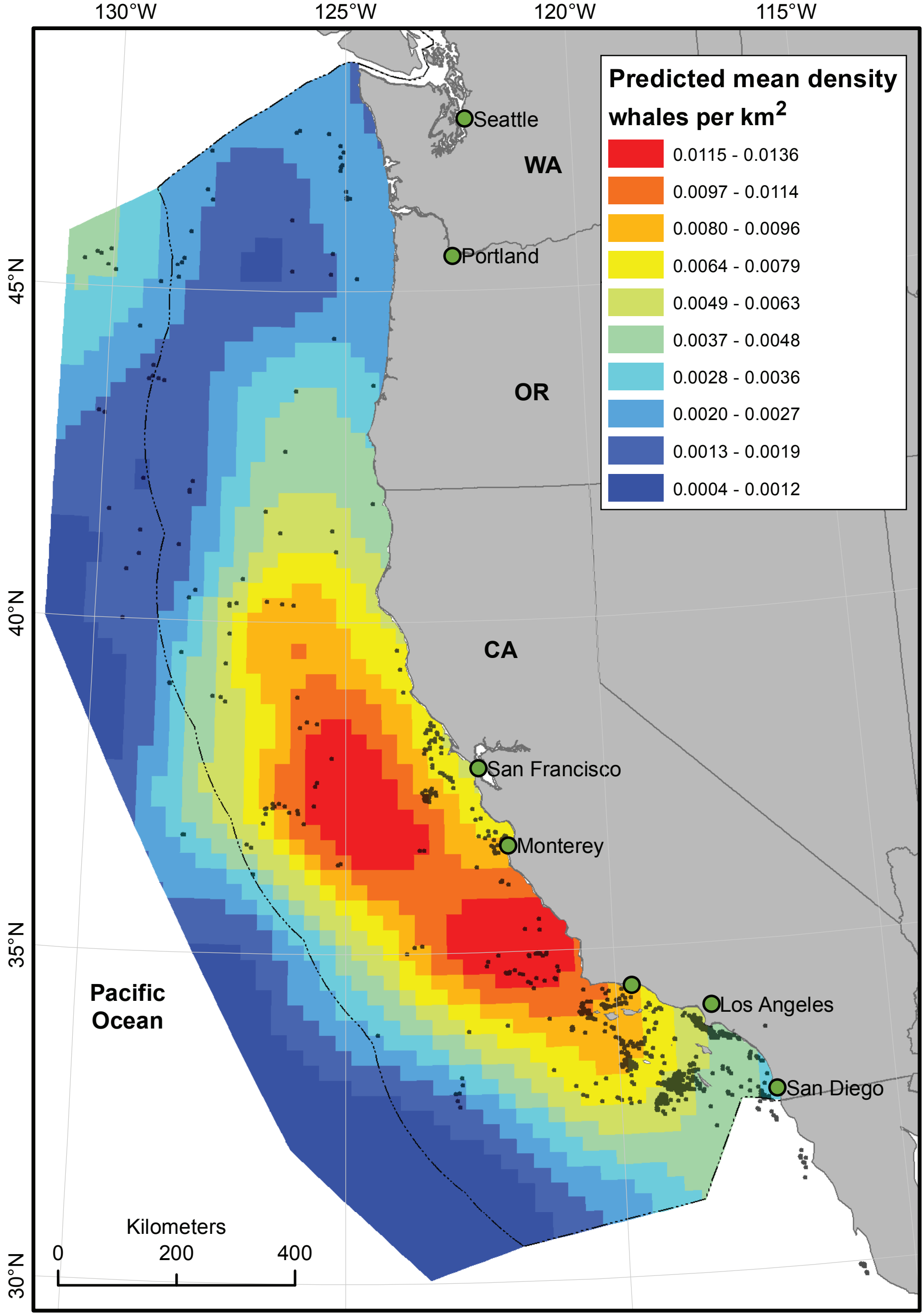

Figure 4.8. Predicted mean densities of fin whales (*Balaenoptera physalus*) from HD models generated from Southwest Fisheries Science Center ship surveys (see Becker et al., 2012a), overlaid with all sightings (including from Cascadia Research small boat and opportunistic surveys)

Coast. Long-range movements along the entire U.S. West Coast do occur as shown by satellite and discovery tags (Mizroch et al., 2009; Falcone et al., 2011b); however, recent data demonstrate that not all fin whales undergo these long-range seasonal migrations. Photo-identification studies of fin whales off the U.S. West Coast show short-range seasonal movements in spring and fall (Falcone et al., 2011a, 2011b). In addition, photo-identification studies off southern California show that within-region movements are more common than inter-regional movements, suggesting that regional subpopulations may exist. Carretta et al. (1995) and Forney & Barlow (1998) also indicate a year-round presence of fin whales off southern California. These relatively recent changes in fin whale distribution in the West Coast region are thought likely to be from post-whaling local population growth, combined with shifts in the overall distribution of fin whales throughout their range (Moore & Barlow, 2011).

Coastal photo-identification surveys (1991 to 2010), in addition to satellite tagging off California and Washington, suggest that the greatest densities of fin whales occur near the continental shelf and slope (Schorr et al., 2010). The behavioral states of these satellite-tagged fin whales could be inferred by their movements over time. Tagged individuals appear to move between likely feeding areas, demonstrating patterns of rapid movement between slopes and plateaus, where they remain for longer periods of time to feed (Schorr et al., 2010). Fin whales feeding on krill in both offshore and coastal areas in the Southern California Bight were also documented via suction-cup attached multisensor archival tags (Goldbogen et al., 2006; Friedlaender et al., 2014).

We considered 1,243 visual boat-based sightings of 2,638 fin whales mostly from nonsystematic surveys collected by Cascadia Research (www.cascadiaresearch.org) and collaborators, conducted primarily in coastal waters from 1991 to 2011 (Figure 4.8). There were areas of concentration of sightings, including (from south to north) Tanner and Cortez Banks area, San Clemente Basin, the shelf edge west of San Nicolas Island, waters off the Palos Verdes Peninsula, waters south and west of San Miguel Island, Santa Lucia Bank, and Guide and Grays Canyons off Washington.

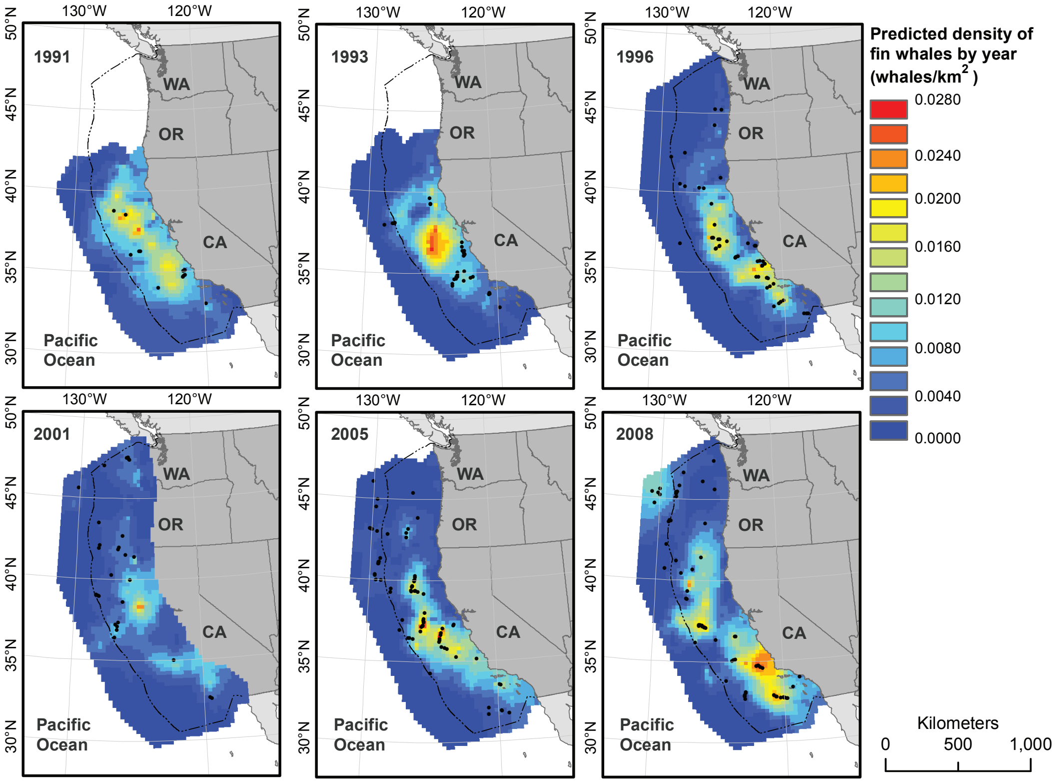

Figure 4.9. Predicted mean densities and sightings (black dots) of fin whales from HD models generated from Southwest Fisheries Science Center ship surveys (see Becker et al., 2012a) for individual years; U.S. EEZ boundary (Pacific Coast) is also shown.

While most of these areas fall within predicted moderately high or highest densities based on the mean HD model (Figure 4.8), there are some significant differences that largely stem from the generally offshore distribution of fin whales and the more coastal and island-specific bias in our small boat-based sightings. The HD model, which is based on surveys that include offshore waters, predicts high densities primarily in offshore waters outside the geographic range of most of our coastal surveys, including offshore waters centered about 100 nmi west of the Gulf of the Farallones and Monterey Bay (central California), and waters west of Point Buchon, from the coast to about 100 nmi offshore. While this latter area includes the Santa Lucia Bank, the predicted high-density area covers a much broader region. One factor that explains some of the discrepancy with the mean density model is the seasonal variation in fin whale distribution. Although fin whales are present year-round off California, their distribution appears to shift somewhat seasonally. Sightings from California Cooperative Oceanic Fisheries Investigations (CalCOFI) surveys off southern California that were conducted during all seasons show fin whales closer to shore in winter and spring and farther offshore in summer and fall (Douglas et al., 2014), coinciding with the survey period for the data used in the HD models. There were also apparent annual differences in fin whale occurrence off the U.S. West Coast and this was somewhat apparent in the annual habitat density models for fin whales (Figure 4.9).

BIAs for fin whales were difficult to determine at this time for a number of reasons, including their offshore distribution (in comparison to our primarily more coastal effort), the poor knowledge of their population structure, and the poor agreement between our areas of concentration from the overall sightings and the HD models. BIAs are therefore not designated here but likely should include offshore areas identified in the HD models as well as occasional concentrations in more coastal areas as documented in our small boat surveys.

Conclusion

In conclusion, 28 BIAs were identified for four cetacean species within the West Coast region based on expert review and synthesis of published and unpublished information. Identified BIAs included feeding areas for blue whales, gray whales, and humpback whales; migratory corridors for gray whales; and small and resident populations for harbor porpoises. The size of the individual BIAs in this region ranged from approximately 171 km^2 for a gray whale feeding area to over 138,000 km^2 for the potential presence migratory corridor BIA for gray whales. The BIAs for feeding blue, gray, and humpback whales represent a relatively small portion of the overall West Coast area (< 5%) but encompass a large majority (77 to 89%) of the thousands of sightings documented and evaluated for each species. This BIA assessment did not include minke whales (*Balaenoptera acutorostrata*), killer whales (*Orcinus orca*), beaked whales (Ziphiidae), and sperm whales (*Physeter macrocephalus*); however, these species should be considered in future efforts to identify BIAs. Also, the species considered herein—blue whales, gray whales, and humpback whales—should be considered for reproductive BIAs.

The IUCN Red List of Threatened Species™
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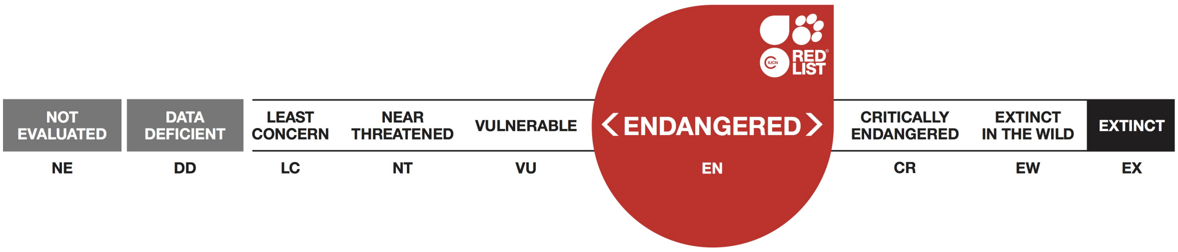
IUCN 2008: T8099A50345475
Scope: Global
Language: English

Eschrichtius robustus (western subpopulation), Western Gray Whale

Assessment by: Cooke, J.G., Taylor, B.L., Reeves, R. & Brownell Jr., R.L.



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Taxonomy

Kingdom	Phylum	Class	Order	Family
Animalia	Chordata	Mammalia	Cetartiodactyla	Eschrichtiidae

Taxon Name: *Eschrichtius robustus (western subpopulation)* (Lilljeborg, 1861)

Parent Species: See *Eschrichtius robustus*

Common Name(s):

- English: Western Gray Whale

Taxonomic Notes:

This is a subpopulation of the Gray Whale, *Eschrichtius robustus.*

Assessment Information

Red List Category & Criteria:	Endangered D ver 3.1
Year Published:	2018
Date Assessed:	January 1, 2018

Justification:

The Gray Whales that summer in the western North Pacific, mainly off northeastern Sakhalin Island and the southeastern coast of Kamchatka, appear to be a genetically and demographically self-contained group and are therefore listed as a subpopulation, even though many of them migrate to wintering areas in the eastern North Pacific. The number of reproductive females is estimated to have been between 51 and 72 in 2016, hence the total number of mature individuals is well below 250, the threshold for Endangered under IUCN Red List criterion D. Historically Gray Whales migrated through Japanese and Korean waters to wintering grounds thought to be located in the South China Sea. Recent sightings and bycatches off Japan and China showed that some individuals, including at least two that were known to feed off Sakhalin Island, migrated through Asian waters in winter and spring. Although one recent record exists of a mother and calf migrating through Japanese waters in spring, it is unclear whether a specific wintering ground still exists in Asian waters. If the western subpopulation were defined to include only those whales that winter in the western North Pacific, then that subpopulation would be classified as Critically Endangered because the number of mature individuals in that group is most probably less than 50.

Previously Published Red List Assessments

2008 – Critically Endangered (CR)
http://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T8099A12885692.en

2000 – Critically Endangered (CR)

1996 – Endangered (EN)

Geographic Range

Range Description:

The main known summering grounds of Gray Whales in the western Pacific are off the northeastern coast of Sakhalin Island (Russian Federation) in the Okhotsk Sea and in bays on the southeastern coast of the Kamchatka Peninsula. They also occur at least occasionally in other coastal waters of the northern Okhotsk Sea (Vladimirov 1994, Weller *et al.* 1999, Yakovlev *et al*. 2011). Historically there was a migration along both coasts of Japan (Sea of Japan and the Pacific Ocean side), the mainland coast of the Sea of Japan, and the Korean Peninsula (Nambu *et al*. 2010). At least 1,700 Gray Whales were taken by modern whaling during 1890-1966 in the Sea of Japan/East Sea, mainly off the coast of Korea, plus unknown numbers in the Yellow Sea (Kato and Kasuya 2002). The catches in the Jangjeon ground (= Changjin northeast Korea) had two peaks, in December and April, which reflect the southbound and northbound migrations, respectively, while the catches in the Ulsan ground (off southeast Korea) were concentrated in December and January.

Until recently, the Gray Whales summering off Sakhalin Island were thought to belong to the historical Asian Gray Whale subpopulation, hence the term "Korean-Okhotsk Gray Whale" used in the Russian literature (Blokhin *et al*. 1985), but evidence from tagged whales (Mate *et al*. 2015) and photographic and genetic matches with whales off Canada and the U.S. and in wintering lagoons along the coast of Baja California, Mexico (Weller *et al.* 2012) show that many of the Sakhalin and Kamchatka whales migrate to the eastern North Pacific in winter.

Although Bowen (1974) speculated that the Asian Gray Whale population was extinct after summarizing available negative findings, this idea was rebutted by Brownell and Chun (1977), who reported that Gray Whales were captured in Korean waters until 1967 and observed there in 1968 and also during research cruises in the Okhotsk Sea in 1967 and 1974. The last confirmed sighting in Korean waters was of two Gray Whales in January 1977 in the Sea of Japan /East Sea (Park 2001, Kim *et al*. 2013). Small numbers of gray whales were observed off Piltun, Sakhalin, in the 1980s (Blokhin *et al*. 1985). About 20 records were documented in Japan between 1990 and 2016, mainly on the Pacific coast (Kato *et al*. 2016). These include at least one female that moved between Sakhalin and Japan and one individual seen in successive years off Sakhalin in summer and off Japan in winter and spring (Weller *et al*. 2008, 2016; Nakamura *et al*. 2017). The last recorded living Gray Whale sighted in Chinese waters was around Wangjia Island, China (36°50'N, western Yellow Sea) in January 1979 (Wang 1984). A Gray Whale stranded near Zhuanghe (Korea Bay, northern Yellow Sea) in December 1996 and died soon after (Zhao 1997). A Gray Whale was caught in fishing gear in the Taiwan Strait (Fujian Province of China) in November 2011 (Wang *et al*. 2015). There are no confirmed records of Gray Whales from the coastal waters of Taiwan (excluding fossils). Two mother-calf pairs were caught in "spring" 1953 (month not stated) in the eastern Gulf of Tonkin off Leizhou Peninsula, Guangdong Province, China (Zhu 2002 cited in Nambu 2010). This is near the Hainan Strait where pre-modern whalers took Gray Whales in January and February in the 19th century (Henderson 1984). The westernmost record is a stranding in October 1994 on the island of Ng⍰c Vùng, Viet Nam, in the western Gulf of Tonkin. The specimen was misidentified at the time as a Fin Whale (*Balaenoptera physalus*), but the skeleton was placed in the Qu⍰ng Ninh Historical Museum where it was recently confirmed to be a Gray Whale (Pham *et al*. 2014). Therefore, it appears that at least some of the Gray Whales that feed in the Okhotsk Sea migrate through Japanese waters in winter and spring. These may be a remnant of the historical Asian population, but it is not known whether any calving and nursery aggregations still exist in the west as

http://dx.doi.org/10.2305/IUCN.UK.2018-2.RLTS.T8099A50345475.en

they do in the east (Baja California, Mexico).

Country Occurrence:

Native: Canada (British Columbia); China; Japan; Mexico (Baja California); Russian Federation (Central Asian Russia); United States (Alaska, California, Oregon, Washington)

Possibly extinct: Korea, Democratic People's Republic of; Korea, Republic of

FAO Marine Fishing Areas:

Native: Pacific - northwest, Pacific - eastern central, Pacific - northeast

Population

Gray Whales were hunted in the western North Pacific in prehistoric times both in Korea (Park 1995, Lee and Robineau 2004) and in the Okhotsk Sea (Krupnik 1984), but to an unknown extent. They were taken by Japanese hand-harpoon whalers in the Sea of Japan starting at least in the 17th century, and in larger numbers by Japanese net whalers in the Sea of Japan and East China Sea, on the Pacific coast of Japan, and along the Korean Peninsula from 1675 to 1890 (Omura 1984, 1988). Gray Whales were also taken by European and American whalers in the Okhotsk Sea from the late 1840s to perhaps the start of the 20th century (Henderson 1984, Reeves *et al.* 2008), and by Russian steam whalers on the southern coast of the Russian Far East and then by Norwegian steam whalers off the Korean Peninsula in the early years of the 20th century (Andrews 1914, Weller *et al.* 2002). Quantitative information is scarce, but it is possible that the western subpopulation was already depleted by the start of modern whaling at the end of the 19th century. During 1890-1966 an estimated 1,800–2,000 Gray Whales were taken off the Korean Peninsula and Japan (Kato and Kasuya 2002). Nearly 85% of these whales were killed off southeastern Korea (Ulsan) while the remainder came primarily from northeastern Korea (Jangjeon, Sinpo and Yujin) with a small number of whales also taken in Japanese waters and the Yellow Sea in the early part of the 20th century. Occasional catches are recorded from China during 1916-1958 (Nambu *et al*. 2010). It is not known whether any Gray Whales have been taken since 1945 in the waters of the Democratic People's Republic of Korea. The Gray Whale population off Sakhalin and Kamchatka has been increasing at a rate of 3.4-4.8% per year, albeit with some fluctuations, over the period 2006-2016 (Cooke 2017). The population in 2016 was estimated at 271-311 whales, excluding calves, of which 175-192 whales were considered predominantly Sakhalin-feeding individuals. The number of breeding females was estimated at 51-72. The nominal number of mature individuals for the purpose of Red List assessment is taken to be twice the number of mature females (102-144 mature individuals). Some of the whales are known through tagging (Mate *et al*. 2015) and photographic matches (Weller *et al*. 2012) to migrate to the eastern North Pacific in winter, including to the wintering lagoons in Baja California, Mexico. While some have been observed to migrate to the western North Pacific (Weller *et al.* 2016), the analysis by Cooke (2017) indicates that the number doing so is 100 or less.

Based on analyses of individual identification data including mother-calf pairs, and the results of paternity analysis of genetic samples (Lang 2010), Cooke *et al.* (2017) concluded that the Gray Whales that summer off Sakhalin and southeastern Kamchatka may constitute a demographically self-contained subpopulation where mating occurs at least preferentially, and possible exclusively, within the subpopulation. Significant genetic differences between Gray Whales sampled off Sakhalin and those sampled in the eastern North Pacific have been found in both mitochondrial and nuclear DNA (Le Duc *et al* 2002, Lang *et al*. 2011). However, another genetic study involving 28 Gray Whales sampled off Sakhalin Island and one sampled in the eastern North Pacific concluded that the putatively 'eastern' individual was no more or less related to the whales sampled in the west than would be expected by chance alone (DeWoody *et al.* 2017).

Current Population Trend: Increasing

Habitat and Ecology (see Appendix for additional information)

Gray Whales are predominantly benthic feeders. The best-studied and apparently main feeding habitat of this subpopulation is the shallow (5-15 m depth) shelf off northeastern Sakhalin Island, particularly off the mouth of Piltun Lagoon, where the main prey species appear to be amphipods and isopods

(Weller *et al.* 1999, Demchenko *et al.* 2016). Mother-calf pairs appear to feed exclusively in the shallow water but other individuals also use an offshore feeding ground in 30-50 m depths southeast of Chayvo Bay where benthic amphipods and possibly cumaceans are apparently the main prey species (Demchenko *et al.* 2016). The prey composition in other Gray Whale feeding areas in the Okhotsk Sea and off Kamchatka is unknown. Historically, Gray Whales were observed to feed during their northbound migration in the East Korean Bay (North Korea; formerly known in English as Broughton Bay) between the two Japanese land stations Sinpo and Yujin in the early 20th century (Andrews 1914, Tago 1922).

Systems: Marine

Threats (see Appendix for additional information)

Three female Gray Whales, including a mother-calf pair, were fatally entangled in net-traps on the Pacific coast of Japan in 2005 (Kato *et al.* 2006). Based on projections, this level of mortality, if continued, would result in a high probability of decline towards extinction (Cooke *et al*. 2006). Following the deaths of two further females, at least one of which was fishery-related, in northern Japan in 2007, the western subpopulation was classified on the IUCN Red List in 2008 as Critically Endangered under criteria C2a(ii) and E (Reilly *et al*. 2008). From 2008, the deliberate killing and marketing of the species was prohibited in Japan (Kato *et al*. 2008), and no fishery-related deaths have been documented there since then. One of the Gray Whales found entrapped in a set net in May 2005 and a Gray Whale carcass that stranded in April 2016 at Ito City (35°N) on the Pacific coast of Japan both exhibited spinal pathologies severe enough in at least the first case to visibly impair mobility (Yamada *et al*. 2016). Since 2013, trap nets for Pacific Salmon have been deployed in the Western Gray Whale feeding ground off northeastern Sakhalin, resulting in two observed entanglements and at least one probable entanglement death (Lowry *et al*. submitted). Based on analysis of photographs, approximately 20% of Gray Whales observed off Sakhalin during 1995-2005 showed evidence of scarring from past entanglements (Bradford *et al*. 2009), but it is not known where the scars were acquired. Lowry *et al*. (submitted) conclude that the coastal salmon set net fishery operating at northeastern Sakhalin, and to a lesser extent elsewhere in the Russian Far East, poses a high risk of entangling Gray Whales from the western subpopulation. They also conclude that bottom-set gillnet, demersal longline, snurrewad, and trap and pot fisheries overlap substantially with Gray Whale distribution in the Russian Far East, and bycatch in those fisheries is possible. One Gray Whale was caught and died in fishing gear off China in the Taiwan Strait in 2011 (Wang *et al*. 2015). In addition to fishery-related hazards, the substantial nearshore industrialization and shipping congestion throughout the migratory corridors of those Gray Whales that migrate through Asian waters in fall, winter and spring increases the likelihood of exposure to ship strikes, chemical pollution, and general disturbance (Weller *et al.* 2002). Offshore gas and oil development in the Okhotsk Sea within 20 km of the primary feeding ground for mother-calf pairs off northeastern Sakhalin Island also represents a potential threat. Potentially harmful activities include geophysical seismic surveying, vessel traffic, and disturbance from construction work (IUCN 2017). However, the continued increase in the numbers of Gray Whales summering off Sakhalin implies that the impacts to date have been sustainable.

Conservation Actions (see Appendix for additional information)

Gray Whales have been legally protected from commercial whaling by the 1946 International Convention for the Regulation of Whaling (ICRW) since its entry into force in 1948, and by its predecessor convention, the Convention for the Regulation of Whaling, since 1935, to which U.S.A., Canada, and Mexico were parties. The ICRW came into effect for the U.S.A., Canada, and the USSR in 1948, Mexico in 1949, Japan in 1951, Republic of Korea in 1978, and China in 1980. Canada withdrew from the ICRW in 1981 but Gray Whales remain protected under Canadian law. Gray Whales have a measure of legal protection in Russian waters through inclusion in the Russian Federation Red Book of Threatened Species: the Korean-Okhotsk population is listed as "Endangered" while the eastern North Pacific population, which occurs in Russian waters in summer, is listed as “Recovery and Restoration”. The Gray Whale has been legally protected in Japan since 2008, and deliberate killing and commercial utilization are prohibited. The species is listed in Appendix I of Convention on International Trade in Endangered Species. Western Gray Whales are listed as endangered under the U.S. Endangered Species Act and are considered depleted and strategic under the U.S. Marine Mammal Protection Act Five range states – Japan, Russian Federation, Republic of Korea, U.S.A. and Mexico – have signed a Memorandum of Cooperation Concerning Conservation Measures for the Western Gray Whale Population. A stakeholders’ workshop to develop a conservation plan is planned for 2018 or 2019.

Credits

Assessor(s):	Cooke, J.G., Taylor, B.L., Reeves, R. & Brownell Jr., R.L.
Reviewer(s):	Weller, D., Mate, B. & Lang, A.
Facilitators(s) and Compiler(s):	Lowry, L.

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External Resources

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Appendix

Habitats

(http://www.iucnredlist.org/technical-documents/classification-schemes)

Habitat	Season	Suitability	Major Importance?
9. Marine Neritic -> 9.1. Marine Neritic - Pelagic	-	Suitable	Yes
10. Marine Oceanic -> 10.1. Marine Oceanic - Epipelagic (0-200m)	-	Suitable	Yes

Threats

(http://www.iucnredlist.org/technical-documents/classification-schemes)

Threat	Timing	Scope	Severity	Impact Score
1. Residential & commercial development -> 1.2. Commercial & industrial areas	Ongoing	Majority (50-90%)	Negligible declines	Low impact: 5
3. Energy production & mining -> 3.1. Oil & gas drilling	Ongoing	Majority (50-90%)	Causing/could cause fluctuations	Medium impact: 6
4. Transportation & service corridors -> 4.3. Shipping lanes	Ongoing	Majority (50-90%)	Negligible declines	Low impact: 5
5. Biological resource use -> 5.4. Fishing & harvesting aquatic resources -> 5.4.1. Intentional use: (subsistence/small scale) [harvest]	Past, unlikely to return	Unknown	Causing/could cause fluctuations	Past impact
5. Biological resource use -> 5.4. Fishing & harvesting aquatic resources -> 5.4.2. Intentional use: (large scale) [harvest]	Past, unlikely to return	Majority (50-90%)	Rapid declines	Past impact
5. Biological resource use -> 5.4. Fishing & harvesting aquatic resources -> 5.4.3. Unintentional effects: (subsistence/small scale) [harvest]	Ongoing	Minority (50%)	Negligible declines	Low impact: 4
5. Biological resource use -> 5.4. Fishing & harvesting aquatic resources -> 5.4.4. Unintentional effects: (large scale) [harvest]	Ongoing	Majority (50-90%)	Causing/could cause fluctuations	Medium impact: 6
9. Pollution -> 9.2. Industrial & military effluents -> 9.2.1. Oil spills	Future	Minority (50%)	Causing/could cause fluctuations	Low impact: 3
9. Pollution -> 9.6. Excess energy -> 9.6.3. Noise pollution	Ongoing	Majority (50-90%)	Causing/could cause fluctuations	Medium impact: 6

Conservation Actions in Place

(http://www.iucnredlist.org/technical-documents/classification-schemes)

Conservation Actions in Place
In-Place Research, Monitoring and Planning

Conservation Actions in Place
Action Recovery plan: No
Systematic monitoring scheme: Yes
In-Place Education
Included in international legislation: Yes

Conservation Actions Needed

(http://www.iucnredlist.org/technical-documents/classification-schemes)

Conservation Actions Needed
1. Land/water protection -> 1.2. Resource & habitat protection
2. Land/water management -> 2.1. Site/area management
3. Species management -> 3.2. Species recovery

Research Needed

(http://www.iucnredlist.org/technical-documents/classification-schemes)

Research Needed
1. Research -> 1.1. Taxonomy
1. Research -> 1.2. Population size, distribution & trends
1. Research -> 1.3. Life history & ecology
1. Research -> 1.5. Threats
2. Conservation Planning -> 2.1. Species Action/Recovery Plan
3. Monitoring -> 3.1. Population trends
3. Monitoring -> 3.4. Habitat trends

Additional Data Fields

Distribution
Continuing decline in area of occupancy (AOO): Unknown
Extreme fluctuations in area of occupancy (AOO): No
Continuing decline in extent of occurrence (EOO): Unknown
Extreme fluctuations in extent of occurrence (EOO): No
Population
Number of mature individuals: 102-144

Population

Continuing decline of mature individuals: No

Extreme fluctuations: No

Population severely fragmented: Unknown

Habitats and Ecology

Continuing decline in area, extent and/or quality of habitat: Unknown

Movement patterns: Full Migrant

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SC/67A/NH/11

Population Assessment Update for Sakhalin Gray Whales, with Reference to Stock Identity

Justin G. Cooke , David W. Weller, Amanda L. Bradford, Olya Sychenko, Alexander M. Burdin, Aimee R. Lang, and Robert L. Brownell, Jr.

INTERNATIONAL
WHALING COMMISSION

Population Assessment Update for Sakhalin Gray Whales, with Reference to Stock Identity

Justin G. Cooke[1], David W. Weller[2], Amanda L. Bradford[3], Olya Sychenko[4],
Alexander M. Burdin[4], Aimee R. Lang[2], and Robert L. Brownell, Jr.[2]

ABSTRACT

The population assessment of gray whales *Eschrichtius robustus* feeding off Sakhalin and Kamchatka is updated, using a population model that alows for multiple feeding and breeding areas. The model is fit to photo-id data collected of Sakhalin during 1995-2015 (Burdin *et al.* 2015), tracking of whales from Sakhalin to the eastern North Pacific (Mate *et al.* 2015), photo-id matches of gray whales between the Sakhalin and Mexico catalogues (Urbán *et al.* 2013) and reported photo-id results from Kamchatka collected during 2004-12 (Yakovlev *et al.* 2013),. The results show that the Sakhalin and Kamchatka feeding populations have been increasing at 2-5% per year over the 10 or 20 years to 2015. The number of non-calf whales in 2016 is estimated to be 320–410, of which 130–170 are predominantly Sakhalin-feeding whales or 180–220 are whales that feed at least occasionally off Sakhalin. A test of the population model output against the results of a paternity analysis by Lang (2010) just rejects the hypothesis of genetic closure of the Sakhalin feeding population ($p < 0.05$) but does not reject the hypothesis of genetic closure of the Sakhalin and Kamchatka feeding populations combined.

Of the predominantly Sakhalin-feeding whales, an estimated 0-50 belong to a possible relict western North Pacific breeding population (which may or may not be genetically closed). Using the IUCN Red List criteria, the Sakhalin and Kamchatka populations, if assessed as a subpopulation, either separately or together, would be classified as Endangered, on the basis of there being between 50 and 250 mature individuals (i.e. ~100-500 individuals when juveniles but not calves are included). If the relict western North Pacific breeding population were assessed as a subpopulation, it would be classified as Critically Endangered, on the basis of there being less than 50 mature individuals.

1. INTRODUCTION

Gray whales (*Eschrichtius robustus*) have been regularly reported during the summer months (June to October) off northeastern Sakhalin Island since the early 1980's (Brownell *et al.* 1997) and have been intensively studied there every year since 1995 (Burdin *et al.* 2015). Initially the Sakhalin gray whales were assumed to be a remnant of the western gray whale population formerly hunted in Korean and southern Japanese waters until the 1960s. The timing of gray whales catches in the Korean grounds was suggestive of a migration to a wintering ground in Asian waters (Kato and Kasuya 2002). However, tagging results and photo-id and genetic matches have shown that at least some of the Sakhalin gray whales migrate to breeding grounds in Mexican waters along with the bulk of the eastern North Pacific gray whale population (Mate *et al.* 2015; Weller *et al.* 2012). Many individuals observed off SE Kamchatka during 2006-11 have been matched with those off Sakhalin (Yakovlev *et al.* 2013, 2014) and some have been matched with whales seen in Mexico.

In an analysis of the data on movement between Sakhalin and the eastern North Pacific, including data from satellite tagging of individuals and photo-id matches between Sakhalin and Mexico, Cooke (2016)

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[1] CEMS, Höllenbergstr. 7, 79312 Emmendingen, Germany. Email: jgc@cems.de
[2] Protected Resources Division, Southwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, 3333 North Torrey Pines Court, La Jolla, CA, 92037-1022 USA
[3] Protected Species Division, Pacific Islands Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Honolulu, HI, USA
[4] Kamchatka Branch of Pacific Institute of Geography, Russian Academy of Sciences, Far East Division, Petropavlovsk, Kamchatka 683000, Russia

concluded that 30-100% of Sakhalin whales migrate in winter to the eastern North Pacific. Thus, those data alone could not confirm or exclude the possibility of a western breeding migration.

However, sightings of Sakhalin-matched gray whale of the Pacific coast of Japan in spring are suggestive of the possibility that at least some of the gray whales seen off Sakhalin undertake a western North Pacific migration that may lead to a western North pacific breeding area whose location is unknown (Weller *et al.* 2016).

On the assumption that Sakhalin whales constituted a separate population, Cooke *et al.* (2016), using photo-id and biopsy data from the Russian Gray Whale Project (Burdin *et al.* 2015), estimated that the feeding aggregation off Sakhalin contained about 175 non-calf individuals by 2016 (although not all of these would be present every year), and had been growing at 2-4% per year.

In this note, the previous assessment is expanded to include additional information, including satellite tag data (Mate *et al.*, 2015), photo-id data collected off Kamchatka, as reported by Yakovlev *et al.* (2013, 2014), and matches between Sakhalin and Mexico (Urbán *et al.*, 2012). The results of the assessment are also compared with the results of a paternity analysis by Lang (2010), to test the hypothesis of genetic closure of the separate or combined feeding populations.

2. MATERIAL AND METHODS

2.1. Data

2.1.1 Photoidentification and sex-determination data

Photo-identification data from the Russian Gray Whale Project were available for each summer season (June to September) from the Piltun area of north-eastern Sakhalin from 1997 to 2015, with some data also collected in 1994 and 1995. A total of 248 distinct individual whales had been catalogued as of 2015. The catalogue has been published and annually updated since 2006 (Weller *et al.* 2006). Yakovlev *et al.* (2012, 2013) list a total of 155 distinct whales identified off SE Kamchatka, of which 85 were matched with whales seen off Sakhalin.

Genetic sex determinations from biopsy were available for 179 whales (89 males and 67 females) for this analysis. A total of 132 calves have been identified. Of these calves, 117 could be linked to an identified mother (in all but one case by observed association, the remaining case genetically). Of the 132 observed calves, 76 have been sexed genetically: 30 female and 46 male.

2.1.2 Tracking and long-range matching data

The three records of known whales successfully satellite-tracked from Sakhalin to the eastern North Pacific (Mate *et al.* 2015) were used.

17 matches between the Sakhalin catalogues and the San Ignacio lagoon catalogue for the years 2006-12 were found (Urbán *et al.* 2013). Of these, 15 were known to be alive as of 2011, of which 13 were known to be born in 2000 or earlier. Because of the low rate of matching of other whales, only whales satisfying these age criteria (born before 2000) and survival not satisfying these age and survival criteria (alive in 2011) were treated as candidates for matching with Mexico.

2.1.3 Paternity

A paternity analysis by Lang (2010) used genotypes collected from 57 mother-calf pairs up to 2007 and compared these with the genotypes of up to 83 males (of which some could be excluded as being too young to sire a calf) to establish paternity. Depending on the criteria used to determine paternity, 26-30 paternities were assigned to known genotyped animals, comprising 17-18 distinct fathers. These data were not used in the model of this paper, because paternity does not directly affect population dynamics, but the estimated population trajectories were compared with the results of Lang's paternity analysis to test the hypothesis of genetic closure.

2.2. Model structure

2.2.1 Basic (single-stock) population model

The core population model is as used by Cooke *et al*. (2016). It is an individually-based stage-structured population model, working in discreet time with a time step of one year.

The reproductive females are divided into three stages: pregnant, lactating, and resting. Females are assumed not to be simultaneously pregnant and lactating. A female can become pregnant immediately following lactation, resulting in a 2-year calving interval (the minimum observed). Optionally, a female can enter the resting phase for one or more years, resulting in a 3-year or longer calving interval. The minimum age at first (successful) pregnancy is 7 years; thereafter, the probability of becoming pregnant is assumed to increase as a logistic function of age, reaching a plateau at age 12.

Immigration is optionally allowed. An “immigrant” is defined as an individual whose mother was not a member of the population. A random number of immigrants enter the population independently each year. Immigrants are assumed to be immature animals. The sex ratio of immigrants is a parameter of the model.

The basic version of the model contains a total of 24 living stages: calves (2 stages: male and female); immature and maturing males (11 stages); adult males (1 stage); immature and maturing females (11 stages); and adult females (3 stages). In addition, there is an unborn stage, a “freshly dead” stage (where a carcass might be found and identified), and a “dead and buried” stage (no further possibility of being found), making a total of 27 stages in the core set.

2.2.2 Multi-stock population model

The main new feature of this analysis is the introduction of multiple feeding and breeding populations.

The “Sakhalin” feeding population is defined to consist of the whales that feed predominantly off Sakhalin but may also be seen off Kamchatka, and possibly in other areas. The “Kamchatka” feeding population is defined as whales that feed predominantly off SE Kamchatka but may also be seen off Sakhalin or in other areas. The two feeding populations are modelled by allowing individuals to have differing probabilities of being encountered in the two areas. These probabilities are determined by the parameters of the sampling model (see below) that are estimated by the data. Many individuals have been seen in both feeding areas, so the two feeding populations are not completely separate. The degree of separation is estimated by the model.

Two breeding populations are assumed: western North Pacific (WNP) and an eastern North Pacific (ENP). The Sakhalin feeding area is assumed to contain a mix of ENP and WNP whales, while the Kamchatka feeding area is assumed to contain only ENP whales. The population is divided into are three feeding/breeding subpopulations: (1) WNP breeding population, feeding off Sakhalin; (2) ENP breeders that feed predominantly off Sakhalin; and (3) ENP breeders that feed predominantly off Kamchatka. In each year, whales in each of the three subpopulations can be in any of the above 27 stages, which results in 81 possible states for each whale. The relative abundance of ENP and WNP whales, and of Sakhalin and Kamchatka feeders, are parameters of the model.

The meaning of “predominantly” is not fixed in advance. The sampling probabilities of whales in each group in each area are parameters of the model, as are the relative numbers of whales in each group. Individuals are not assigned definitively to either group, but the posterior likelihood of each whale belonging to each group depends in its sampling history, and is estimated together with all the parameters of the model.

The possibility that some Kamchatka-feeding whales belong to the WNP breeding population was not considered in this analysis, although in principle this would be possible.

2.2.3 Sampling model

2.2.3.1 Photo-id sampling

An animal is 'sampled' in a given year when it is photographed in that year, and the photographs have been processed and assigned to an existing known whale in the catalogue, or to a new whale which is added to the catalogue. A lactating (or post-lactation) female may be sampled alone or with its calf; likewise, a calf may be sample alone or with its mother. The probability that a mother-calf pair has separated before it is recorded is a parameter of the model.

An animal may be sampled off Sakhalin, off Kamchatka or off Mexico. The sampling probabilities off Sakhalin and Kamchatka are parameters of the model allowed to vary by year, location, stage and individual. Individual (as opposed to stage-related) heterogeneity in sampling probability is modelled by assigning each individual with equal probability to one of a number of availability strata. The sampling probability may also depend on various interactions between the above factors, as determined by the model-selection process.

The required number of strata is determined by the model-selection process (see below). When there are m strata, each whale can be in a total of $81m$ different states.

The sampling probability for Mexico was estimated externally by Cooke (2016). The sampling probability of an "adult" whale (i.e. one meeting the age criteria defined above) in the Mexican breeding grounds was estimated at 0.054 per year, or 0.32 in total for the years 2006-12 combined. There may be scope for refining this estimate.

2.2.3.2 Satellite tracking

We assume that the tracking success probability is independent of breeding location. That is, we assume that if the three whales tracked from Sakhalin to the eastern North Pacific had instead migrated south in the western North Pacific, they would have been tracked there too. With this assumption, we condition on the actual number and identity of whales successfully tracked, and do not need to model the tracking probability.

This approach implies a qualitative difference in the evidentiary value of satellite-tracked animals versus long-range photo-id matches: for photo-id, the relevant sampling probability must be known or estimated, but this is not necessary for tracked animals.

2.3. Likelihood, model fitting and model selection

Table 1 lists the factors/terms included in each of the alternative models fitted. Each model was first fitted by maximum likelihood (REML) to produce estimates of model parameters and of the population trajectory. The factors/terms to include in the model were selected using the AIC criterion, to identify a preferred model. The Bayesian posterior distribution of the population trajectory was sampled for the preferred model. Full details of the model and fitting procedure are given by Cooke *et al*. (2016).

In summary, each individual has a range of potential biographies, each of which consist of a time series of its putative true state in each year. Some aspects of the state are assumed to remain constant over its lifetime, such as sex and membership of a feeding and/or breeding group. Other aspects, such as age, reproductive status, live vs. dead, change from year to year according to the transition probabilities.

In addition, each individual has an observed history. The observed history may be null for some individuals (i.e. individuals that exist but have not yet been sampled). The likelihood is calculated by comparing each putative biography with the observed history. Some aspects of the comparison are probabilistic. For example, whether an individual is sampled in a given area in a given year: the likelihood depends on the relevant sampling probabilities. Other aspects, such as sex or membership of a breeding stock, are of an either/or nature. For example, if a whale is tracked to the eastern North Pacific, all its potential biographies that involve it being a western breeder get assigned a zero likelihood. Likewise, if a whale is determined through genetic sampling to be male, all the potential biographies that involve it being female get assigned a zero likelihood.

2.4. Testing genetic closure

No paternity data were used in the model-fitting process, because paternity is assumed not to affect population dynamics. However, the output of the preferred model was used to compute the expected distribution of number of identified paternities under the assumption that all paternities were from within the population (genetic closure) and there is random mating. This was compared with the observed number of identified paternities in order to test the genetic closure hypothesis. A range of 7-12 years was assumed for the age of effective reproductive maturity for males.

Two genetic closure hypotheses were tested: (i) paternities are within each feeding population; (ii) paternities are not necessarily within each feeding population, but are within the two feeding populations combined.

For each hypothesis, the comparison was performed by generating a random sample of 500 realizations from the posterior distribution of the individually-based population trajectories. In each realization, the father of each calf included in Lang's paternity analysis was selected randomly from the pool of potential fathers under the given hypothesis (i.e. reproductively mature males alive in the given population in the year of conception of the calf – assumed to be 1 year before the birth year). The size of the subset of these assigned fathers that were included in the genetic sample used in Lang's analysis was recorded for each realization. This produces a posterior distribution for the predicted number of known paternities, which can be compared with the observed number.

3. RESULTS

3.1. Model selection

Table 1 shows the results of fitting various models sequentially. Case A represents the minimal reasonable model, because the sampling probability is a function of the effort expended in each area by year. The inclusion of separate feeding populations differentially sampled in the two areas (case B) improves the fit very substantially (ΔAIC = −701) and shows that the two areas (Sakhalin and Kamchatka) cannot be treated as an homogenous unit. Including stage-specific availability factors (case C) improves the fit (ΔAIC = −8.3) and this factor was retained. Allowing for interaction between location and stage (case D) improves the fit substantially (ΔAIC = −147). Allowing for individual heterogeneity in the sampling probability by location and population using 5 strata (case E) substantially improved the fit further (ΔAIC = –151). Allowing for the pregnancy rate to vary by year (case F) also improved the fit (ΔAIC = −18,7), and this factor was retained. Including annual variation in calf mortality (case G) worsened the fit (ΔAIC > 0); this factor was not retained. Reducing (case H) or increasing (case I) the number of strata led to a worse fit in each case (ΔAIC > 0). The original choice of 5 strata for modelling individual heterogeneity was therefore retained. Allowing for immigration (whales born to mothers outside the population) into the two populations (case J) worsened the fit (ΔAIC > 0).

Table 1. Results of fitting various models in a sequential process.

Case	Model	AIC
A	Sampling:Location.Year	5 027.4
B	A + Sampling:Location.Population	4 326.1
C	B + Sampling:Stage	4 317.9
D	C + Sampling:Location.Population.Stage	4 170.8
E	D + Sampling:Location.Population.Stratum(5)	4 019.9
F	E + Pregnancy:Year	4 001.2
G	F + CalfSurvival:Year	4 029.7
H	F with 3 strata	4 019.4
I	F with 8 strata	4 044.6
J	F + Immigration:Population	4 020.3

The preferred model was, therefore, case F, where the sampling probability depends on interactions between location, feeding population and stage and between location, feeding population and stratum, and there is annual variability in pregnancy rate, but no annual variability in calf survival, and no immigration.

3.2. Population size and trajectories

A random sample of 50 trajectories from the posterior distribution of population trajectories is shown in Fig. 1 for (a) the aged 1+ population and (b) reproductive females only. In each plot the trajectories are shown for (i) the entire Sakhalin and Kamchatka feeding population; (ii) the Sakhalin feeding population only; and (iii) the western North Pacific breeding subset of the Sakhalin feeding population.

In contrast to the results of Cooke *et al*. (2016) no annual variability in the calf survival rate was found. The cause of the difference appears to be inclusion of data from Kamchatka: some of the calves which went "missing" from Sakhalin and would have been presumed dead in the analysis of Cooke *et al* (2016), were sighted alive in Kamchatka. The "pregnancy rate" (strictly, the production rate of live calves that survive their first migration to the feeding grounds) was, as before, found to show significant annual variability.

The results show that the Sakhalin and Kamchatka feeding populations have been increasing at 3-5% p.a. over the 10 (or 20) years to 2015. The total aged 1+ (non-calf) population for the combined is estimated at 321−412 whales in 2016 (95% confidence interval). The exclusively and predominantly Sakhalin-feeding population is estimated at 133−168 non-calf whales in 2016.

The new estimate for the Sakhalin feeding population is slightly lower than the estimate of 158−193 by Cooke *et al.* (2016) but the earlier analysis defined the Sakhalin population to include all whales that visit Sakhalin at some time in their lives, including those who visit only occasionally. The new estimate is for predominantly Sakhalin-feeding whales. Using the previous definition, the new estimate for the Sakhalin population in 2016 would be 182−222.

These estimates for Sakhalin whales include both eastern and western North Pacific breeders, if there are any. If the Sakhalin whales contain a subgroup that breeds in the western North Pacific, this part is estimated to have contained up to 50 whales in 2016 (95% CI 2−47). Because the model input contains no definite records of a western breeder, the posterior distribution for the number of western breeders essentially runs from zero to a (probabilistic) upper bound determined by the number of definite eastern breeders that have been observed.

3.3. Genetic closure

The predicted number of paternities was found to be insensitive to the choice of male age at first reproduction, varying by only about 1 paternity across the range 7-12 for male age at first reproduction. This uncertainty was subsumed into the confidence intervals for each hypothesis.
On the assumption that mating occurs only within each feeding population, the population model predicts, with 95% probability, 31−47 identified paternities on Lang's (2010) sample; if mating is random across the two feeding populations combined, the model predicts 14−27 identified paternities.

The observed value of 26−30 lies between the above two ranges. The result suggests that there is preferential, but not exclusive, mating within the Sakhalin feeding aggregation. The hypothesis of mating exclusively within the Sakhalin feeding population is just rejected ($p < 0.05$). We conclude that the Sakhalin feeding aggregation is probably not genetically closed but that the Sakhalin and Kamchatka feeding aggregations, taken together, may be genetically closed. However, genetic data from Kamchatka would be required to confirm this.

4. DISCUSSION

If these population estimates were used to update the IUCN Red List status, and either just Sakhalin or Sakhalin and Kamchatka whales are considered to constitute a distinct subpopulation, then their status would be Endangered, on the basis of there being more than 50 but less than 250 mature animals (mature animals make up about half the population). If there is a distinct western North Pacific breeding stock, this would be classified as Critically Endangered, because the range of estimates for the number of mature animals is well below 50. Obtaining further information on the existence, nature and status of the relict western North Pacific breeding population is clearly a high priority.

ACKNOWLEDGEMENTS

We would like to acknowledge the work of all the volunteer biologists over the years who have assisted with data collection. We are also grateful to the International Fund for Animal Welfare (Marine Conservation Program) which has provided full or partial funding for each of the last 15 field seasons at Piltun Bay.

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Fig. 1. Sample of population trajectories

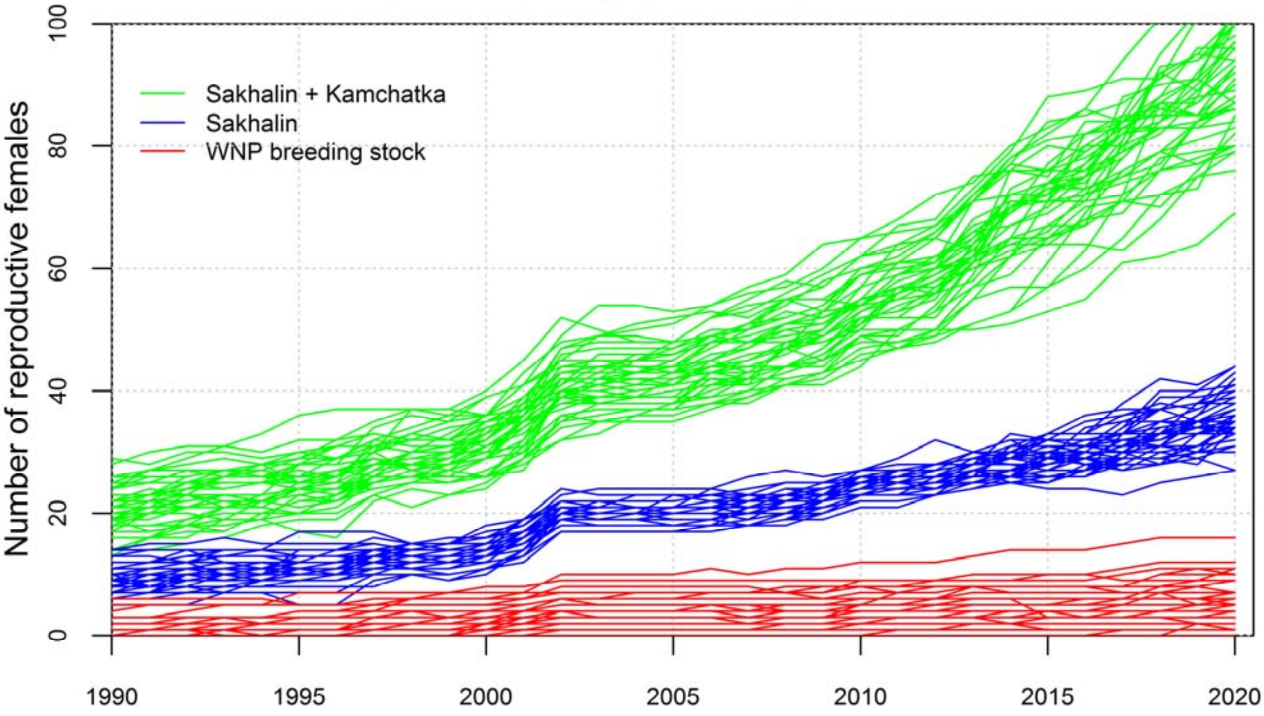

Fig. 1a. Sample of 50 trajectories from the posterior distribution for the preferred model. Reproductive females.

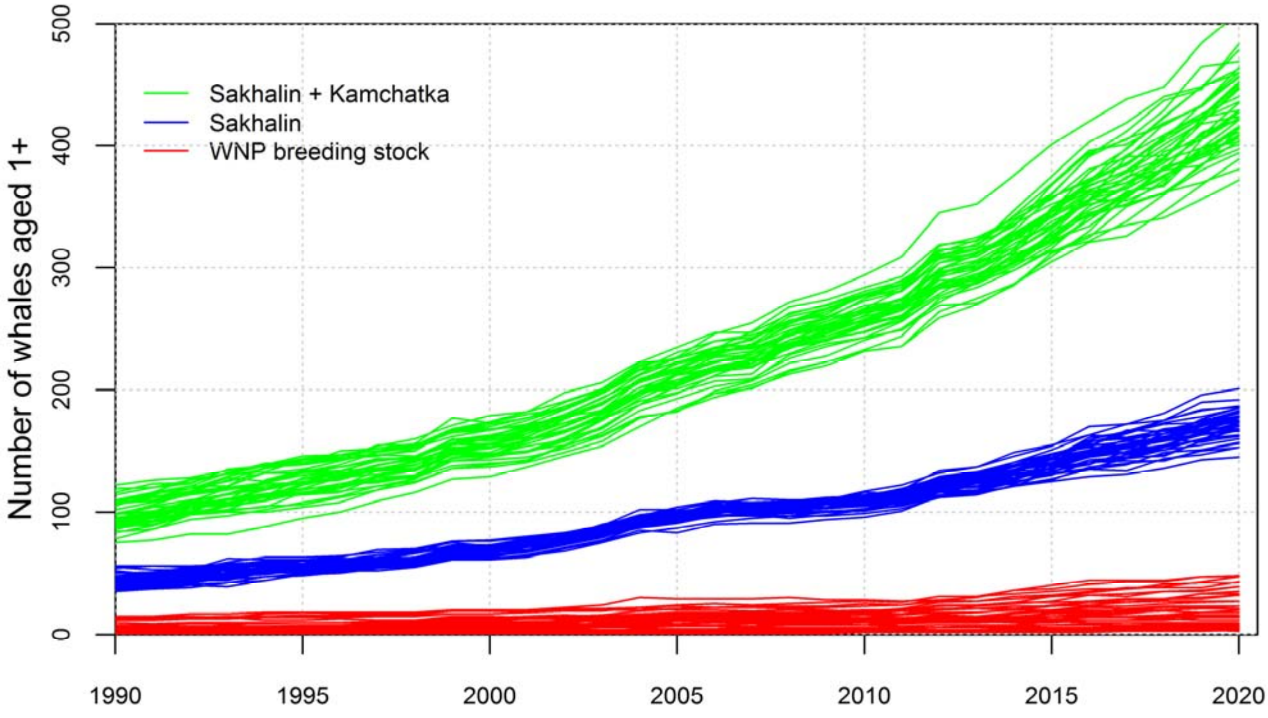

Fig. 1b. Sample of 50 trajectories from the posterior distribution for the preferred model. All animals aged 1+.

SC/68A/CMP/11 Rev1

New information on the gray whale migratory movements between the western and eastern North Pacific

J. Urbán R., D. Weller, S. Martínez A., O. Tyurneva, A. Bradford, A. Burdin, A. Lang, S. Swartz, O. Sychenko, L. Viloria-Gómora and Y. Yakovlev

INTERNATIONAL
WHALING COMMISSION

New information on the gray whale migratory movements between the western and eastern North Pacific.

J. Urbán R[1]., D. Weller[2], S. Martínez A[1]., O. Tyurneva[3], A. Bradford[4], A. Burdin[5], A. Lang[2], S. Swartz[6], O. Sychenko[5] , L. Viloria-Gómora[1], and Y. Yakovlev[3],

[1] *Departamento de Ciencias Marinas y Costeras, Universidad Autónoma de Baja California Sur, La Paz, B.C.S., Mexico*
[2] *Southwest Fisheries Science Center, National Marine Fisheries Service, NOAA Fisheries, La Jolla, CA, USA*
[3] *A.V. Zhirmunsky National Scientific Center of Marine Biology of the Far Eastern Branch of the Russian Academy of Sciences, Palchevsky 17, 690041 Vladivostok, RUSSIA.*
[4] *Pacific Islands Fisheries Science Center, National Marine Fisheries Service, NOAA Fisheries, Honolulu, HI, USA*
[5] *Kamchatka Branch of Pacific Institute of Geography, Far East Branch - Russian Academy of Sciences, Petropavlovsk, Kamchatka, Russia*
[6] *Laguna San Ignacio Ecosystem Science Program, Darnestown, MD, USA*

ABSTRACT

Gray whales have traditionally been considered to consist of two populations, one in the western North Pacific (WNP) and the other in the eastern North Pacific (ENP). The ENP population ranges from wintering areas off Baja California, Mexico, to summer feeding areas in the Bering, Beaufort, and Chukchi Seas. The WNP population feeds off Sakhalin Island and southeast Kamchatka, Russia. Historical evidence indicates that the South China Sea may have been used as a wintering ground in the WNP. Genetic, telemetry and photo-identification comparisons between the ENP and the WNP show some degree of population mixing during the winter. Here we present a multinational effort to evaluate trans-Pacific movements of gray whales identified in both the ENP and WNP. Images of 379 whales identified on the summer feeding grounds off Russia (316 from Sakhalin; 150 from Kamchatka), were compared to 10,685 individuals identified in the wintering lagoons of Baja California, Mexico (1,590 from Laguna Ojo de Liebre; 7,151 from Laguna San Ignacio; and 1,994 from Bahia Magdalena). A total of 43 matches were found, including: 14 Sakhalin-Kamchatka-Mexico, 25 Sakhalin-Mexico, and 4 Kamchatka-Mexico. These matches consist of 22 females, 13 males, and 8 whales of unknown sex. Thirteen whales were observed making round trips (summer-winter-summer), 11 with winter in Mexico and the following summer in Russia, and 6 with summer in Russia and the following winter in Mexico. The others were matched in non-sequential years. These 43 matches, in combination with 11 previous matches, result in 54 gray whales being linked between Russia and Mexico. Movements between the WNP and ENP represents 14.2% of gray whales identified off Sakhalin Island and Kamchatka, and the 0.5% of the gray whales identified in the breeding lagoon of the west coast of Baja California peninsula Mexico.

INTRODUCTION

The gray whale (*Eschrichtius robustus*) has been historically considered to consist of two populations, the western North Pacific (WNP) and eastern North Pacific (ENP) populations (Reilly *et al*., 2008). The ENP population ranges from calving areas off Baja California, Mexico, to feeding areas in the Bering, Beaufort, and Chukchi Seas. The WNP population feeds in the Okhotsk Sea off Sakhalin Island, Russia, and in nearshore waters of the southeastern Kamchatka Peninsula, historical evidence indicates that areas in the South China Sea were used as wintering grounds (Weller *et al*. 2002).

The Western stock is listed as critically endangered whereas the Eastern Pacific population is of least concern (Reilly *et al.*, 2008). Both stocks were extensively harvested during commercial whaling (Henderson 1984, Weller *et al*. 2002, Reeves *et al*. 2010). The ENP population is currently estimated at 19126 (cv= 0.071) individuals (Laake *et al*. 2009. The most recent assessment of the WNP subpopulation in the Okhotsk Sea (Sakhalin Island + east coast of Kamchatka), using a Bayesian individual-based stage-structured model, resulted in a median 1+ (non-calf) estimate of 321-412 individuals, and 130-170 for Sakhalin feeding whales in 2016 (95% confidence interval) (Cooke *et al*. 2016).

Research on gray whales in the WNP has been ongoing since 1995, predominantly on the primary feeding ground off northeastern Sakhalin Island, including the Piltun area (52°20' N–53°30' N), stretching 120 km along the shore of Piltun Bay, and the Offshore area, located further offshore from Chayvo Bay (51°40' N–52°20' N) (Weller *et al*. 1999, 2012; Bradford *et al*., 2008; Yakovlev *et al*., 2009; Lang *et al*. 2011), and more recently off southeastern Kamchatka (Vertyankin *et al*. 2004, Tyurneva *et al*. 2010, Burdin *et al*. 2011). These studies monitor gray whales using photo-identification methods, as gray whales are individually identifiable based on unique, permanent pigmentation features (Darling 1984). These studies have documented a pronounced seasonal site fidelity and inter-annual return of known individuals in the Sakhalin coasts (Weller *et al*. 1999, 2002, Bradford 2011); as well as movements of individuals, including reproductive females and calves, between the coastal waters off Sakhalin and the southern and eastern coast of Kamchatka (Tyurneva *et al*. 2010, 2018; Burdin *et al*. 2011).

Current data from the historical migratory corridor(s) of the WNP are limited, and data from the presumed wintering area(s) are essentially unavailable (Weller *et al*. 2012). There is only one known photographic match of a fatally entrapped female in set nets along the Pacific coast of Honshu, Japan in January 2007 who photographed as a calf in Sakhalin feeding ground in July and August 2006 (Weller *et al*. 2008).

Lang (2010) reported that two adult individuals from the WNP, sampled off Sakhalin in 1998 and 2004, matched the microsatellite genotypes, mtDNA haplotypes, and sexes of 2 whales sampled off Santa Barbara, California, USA. This report was the first to suggest that some level of interchange might be occurring between the WNP and ENP.

During the summers of 2010 and 2011, seven adult gray whales were tagging in Sakhalin Island, three of them transmit long enough to document their migration route. These three whales went across the Bering Sea to the Gulf of Alaska, one of them, “Varvara,” traveled south within 103 km of Cabo San Lucas, Baja California Sur, México, and return to Sakhalin Island after 172 days of tagging (Mate *et al*., 2015)

Using photographic comparison of photo-identified gray whales, Weller *et al*. (2012) report the first ten matches between the WPN and ENP, six between whales photographed in Sakhalin Island and Vancouver Island, Canada, and four between Sakhalin Island and San Ignacio Lagoon, Mexico.

Following a recommendation of the Scientific Committee of the International Whaling Commission, Urbán *et al*. (2012; 2013) reported the results of the *Collaborative Pacific wide study on population*

Structure and Movement patterns of North Pacific gray whales, where 23 photographic matches between the WNP and the breeding lagoons from the Baja California Peninsula, Mexico, were found.

Here we present new information on trans-Pacific movements of gray whales photo-identified in both the ENP and WNP.

METHODS

The comparison was made base on the following sources:

Russia (Fig 1):

Sakhalin Island:

- *Burdin, M.A., Weller W. D., Sychenko, A.O. and Bradford, L.A. Western gray whales off Sakhalin Island, Russia: A catalog of photo-identified individuals. (1994-2016) 261 individuals.* ***(WGW)***
- *Tyurneva. Y.O. and Yakovlev, M.Y. The Western Pacific gray whales of Sakhalin island (2002-2011) Learning about a population of whales through photographs. 172 individuals.* ***(KOGW)***

Kamchatka Peninsula:

- *Tyurneva, O. and Vertyankin, V. The North Pacific Master gray whale catalogue (2004-2011). 150 ids. 150 individuals.* ***(KamGW)***

Mexico (Fig 2):

- *Conner. L. and Hillman E. Studies Field School Gray whale photo ID catalog (1998-2010). Bahía Magdalena. 233 individuals.*
- *Catalogues from Bahía Magdalena and Bahia Almejas. Universidad Autónoma de Baja California Sur and Laguna San Ignacio Ecosystem Science Program (2012-2018). 1944 individuals.*
- *Catalog from Laguna San Ignacio. Universidad Autónoma de Baja California Sur and Laguna San Ignacio Ecosystem Science Program (2005-2019). 7151 individuals.*
- *Catalog from Laguna Ojo de Liebre. Universidad Autónoma de Baja California Sur and Laguna San Ignacio Ecosystem Science Program (2001-2003, 2013-2015). 1590 individuals.*

The comparison was done with the software “Hotspotter” (http://www.cs.rpi.edu/hotspotter/), and we did the comparisons twice: Mexican vs Russian, and Russian vs Mexican photographs. Sometimes this software cannot find the match in one way, depending on the photo-id quality.

RESULTS

The comparison among the three catalogs from Russia (316 from Sakhalin; 150 from Kamchatka) result on: 229 individuals from Sakhalin, 63 from Kamchatka, and 87 from both Sakhalin and Kamchatka, with a total of 379 photo-identified whales from Russia (Fig 3).

These 379 whales from Russia were compared to 10,685 individuals photo-identified in the wintering lagoons of Baja California, Mexico (1,590 from Laguna Ojo de Liebre; 7,151 from Laguna San Ignacio; and 1,994 from Bahia Magdalena). A total of 43 matches were found, including: 14 Sakhalin-Kamchatka-Mexico, 25 Sakhalin-Mexico, and 4 Kamchatka-Mexico.

These matches consist of 22 females, 13 males, and 8 whales of unknown sex. 13 whales (6 females, 6 males and one of unknown sex) were observed making round trips (summer-winter-summer), 11 whales (9 females and 2 males) with winter in Mexico and the following summer in Russia, and 6 whales (4 females, one males and one of unknown sex) with summer in Russia and the following winter in Mexico. The other whales matched were in non-sequential years. (Tables 1, 2 and 3)

These 43 matches, in combination with 11 previous matches, result in 54 gray whales being linked between Russia and the eastern North Pacific (Table 4).

Movements between the WNP and ENP represents 14.2% of 379 gray whales identified off Sakhalin Island and Kamchatka, Russia, between 1994 and 2016, and the 0.5% of the 10,685 gray whales identified in the breeding lagoon of the west coast of Baja California peninsula, Mexico, between 1998 and 2019.

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Figure 1. Photographic catalogues from the feeding areas in Russia

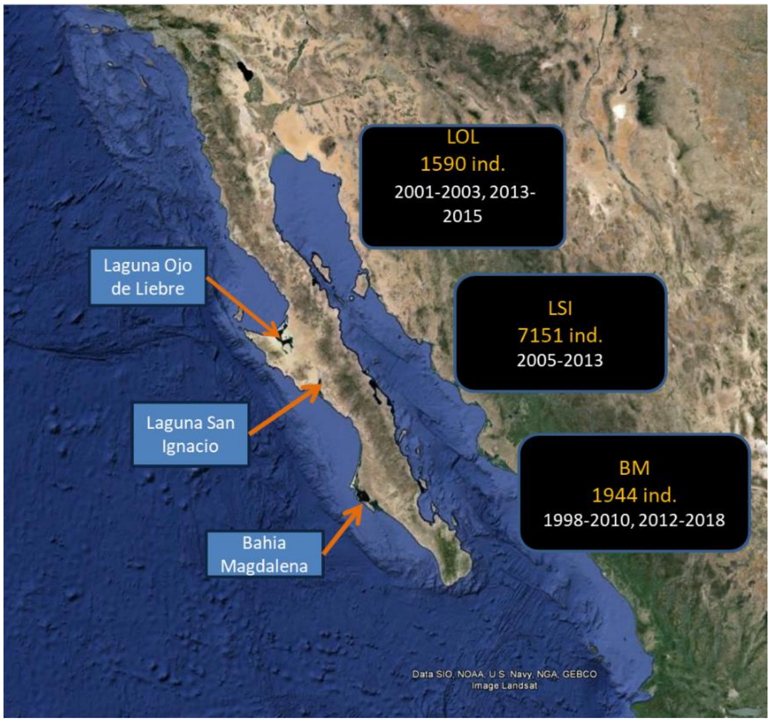
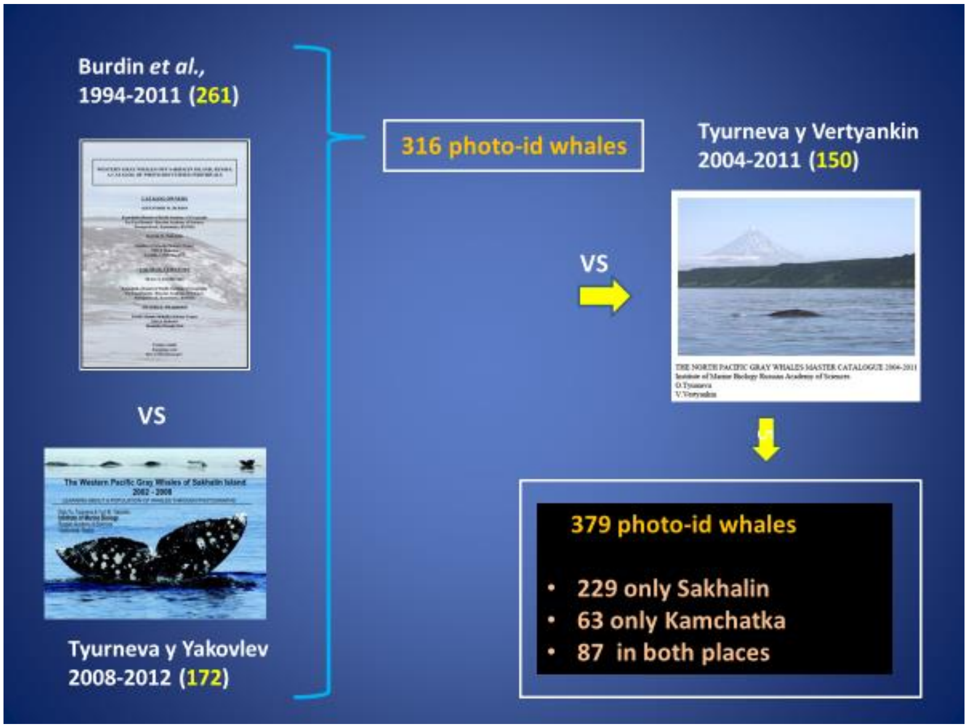


Figure 2. Photographic catalogues in the breeding grounds in Mexico



Burdin *et al.*,
1994-2011 (261)

VS

The Western Pacific Gray Whales of Sakhalin Island
2002 - 2008

Tyurneva y Yakovlev
2008-2012 (172)

316 photo-id whales

Tyurneva y Vertyankin
2004-2011 (150)

VS

THE NORTH PACIFIC GRAY WHALES MASTER CATALOGUE 2004-2011
Institute of Marine Biology Russian Academy of Sciences
O.Tyurneva
V.Vertyankin

379 photo-id whales

- 229 only Sakhalin
- 63 only Kamchatka
- 87 in both places

Figure 3. Catalogs comparison in Russia.

Table 1. Females

Catalog: WGW: Burdin-Weller *et al* (Sakhalin 1994-2016), KOGW: Tyurneva and Yakovlev (Sakhalin 2002-2008), KAMGW: Tyurneva and Yakovlev (Kamchatka 2004-2011). W: Whales without calf, MC: Mother with calf, S: Laguna San Ignacio, O: Laguna Ojo de Liebre, B: Bahia Magdalena. Cells with color: Whales seen in Mexico/ and Russia. Orange: Mother with calf, blue: whale without calf.

WGW	KOGW	KAMGW	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
1	7						W					W			MC		MC		MCS	
3	114					W	W	W			W		MCS/MC		MC		MC			
29	28	45	W	W	W	W	W		W		W	MCS/W	W	W						
30	8		W		MCB/MC			W												
38	64	60	W	W	W	MC	WB/W	W	MC			W	W	MC	W	MC		MCB/W		
42	90	1			W	W	W				WS		W	MCS/W	W			W		MCS
63	47	13	W	W			W		W	MCS/W		W	MC		W		W	W		MCS-MCB
76	62		MCO/W	W	MC	W	MC	W	MC	W	W	W	MC	W	MC		W			
85	51		W	W		W	W			MC/MCS	W	WS	W	MCS	W		MCS			
87	40	113	W		MCO/MC	W	W			W			W							
92	15		MC	W			W	W	MC		MC		MC	W	MC		MC/MCS			
103	119		W	W		W	W		WS				MCS/W		W					
107	108			AC	W	W	W	W					MC		MCO/MC		MC			
116				W													MCS			
129	77	73			W				W			W	W		WB					
135	95	8				AC									W			W		WS
206	204												W				MCS			
207	212												WS	W	MCS				MCS	
	122															MCO				
		106														MCS			MCS	
		117												MCS						

Table 2. Males.

AC: Accompanied calf, UC: Unaccompanied calf

WGW	KOGW	KAMGW	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
20	80					W	W	W		WS	W		W		W		W						
27	2		W	W	W	WO/W		W	W	W	W		W	W	W								
28	59	122	W	W	W		W	W	W	WS/W	W		W		W	W	W	W	W				
33	116		W	W	W	W	W	W	W	W	WB/W		W			W	W						
47	9		W	W	W	W	W	W	W		W	W		W	W	WS/W	W						
52	26		WS/W	W	W	W	W		W	W	WS	W	W	WS/W	W	W	W	W	W	W			
68	43	118	W		W			W	W	W	W						W						WS
69	113			W	W	W	W	W		WS		W	W		W	W	W	W					
82	25	132	W	W		W		W	W		W		WS/W		W	W		WS/W					
84	29		W	W	W	W	W	W	W	W	W	W	WS/W	W	W		W	WS					
91	137	42		UC					W		W	W	W		WS/W		W	W					
110	132	2				AC			W					W	WS/W		W						
112	81					AC	W	W	W	W	W	W	W	W	W		W	W	W		WS		

Table 3. Unknown

WGW	KOGW	KAMGW	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
50	100										WO					
94	57		WS	W				W								
181	172					W	W	W		W	W		W			WB
200	191							AC	WS/W							
	166	15				WS										
		36							WS	WS						
		114						WS								
		134						WS								

Table 4. Matches between Russia and the eastern North Pacific. (Source: 1 Weller at al. 2012; 2 Lang, 2010; 3 Mate et al. 2015; 4 not reported).

WGW	KOGW	KamGW	Sex	Place	Technique	Source
2	17		M	Pacific North West	genetic/photo	1
4	35		M	California	photo	4
16	11		M	Santa Barbara	genetic	2
32	68		M	Pacific North West	Sat tag/photo	3
35	94		M	Pacific North West	photo	1
78	41		?	Pacific North West	photo	1
102	1		?	California	photo	4
119	75	26	F	Pacific North West	photo	1
166	152	50	M	California	genetic/photo	4
		81	?	Pacific North West	photo	4
		100	?	California	photo	4